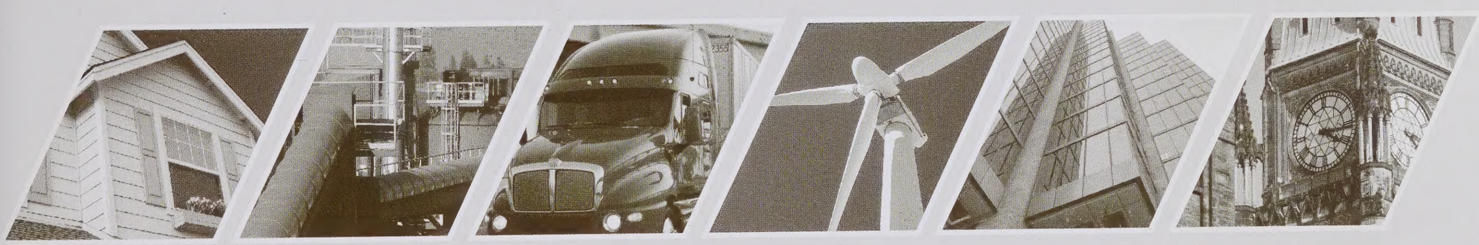
Natural Resources Canada
Ressources naturelles Canada

ecoENERGY
an ecoACTION initiative

Improving Energy Performance in Canada



Report to Parliament Under the *Energy Efficiency Act*
For the Fiscal Year 2009–2010

Canada

The digital mosaic of Canada that appears on the cover of this publication is produced by Natural Resources Canada (Canada Centre for Remote Sensing) and is a composite of individual satellite images. The differences in the density of vegetation are illustrated through shading.

Publishing by the authority of the Minister of Natural Resources Canada
Government of Canada

Aussi disponible en français sous le titre : Améliorer le rendement énergétique au Canada – Rapport au Parlement en vertu de la *Loi sur l'efficacité énergétique* pour l'année financière 2009–2010

Cat. no. M141-10/2010E (Print)
ISBN 978-1-100-17531-7

Cat. no. M141-10/2010E-PDF (On-line)
ISBN 978-1-100-17532-4

To obtain additional copies of this or other free publications on energy efficiency, please contact:

Energy Publications
Office of Energy Efficiency
Natural Resources Canada
c/o St. Joseph Communications
Order Processing Unit
1165 Kenaston Street
PO Box 9809 Station T
Ottawa ON K1G 6S1
Tel.: 1-800-387-2000 (toll-free)
Fax: 613-740-3114
TTY: 613-996-4397 (teletype for the hearing-impaired)

You can also view or order most Office of Energy Efficiency publications on-line.
Visit our Virtual Library at oee.nrcan.gc.ca/publications. The Office of Energy Efficiency's Web site is at oee.nrcan.gc.ca.

PRINTED IN CANADA IMPRIMÉ AU CANADA Recycled paper

Table of Contents

List of Figures and Tables

Figures

Tables

Minister's Foreword

I am pleased to introduce the *2009/2010 Report to Parliament on Improving Energy Performance in Canada*. This Government believes that improving energy efficiency is one of the fastest, greenest and most-cost effective ways to save energy, increase domestic jobs, and increase energy security.

Over the past year, through its ecoENERGY initiatives, the Government of Canada has successfully promoted energy efficiency and the use of alternative energy. The goal has been to reduce greenhouse gas emissions and save Canadians money. More than 500,000 individuals and businesses have made the choice to reduce their energy consumption by participating in our ecoENERGY initiatives.

Our Government has also amended the *Energy Efficiency Regulations* to complement the ecoENERGY initiatives. The goal of the Regulations is to eliminate the least energy-efficient products from the Canadian marketplace. Amendment 11 proposes minimum energy performance standards or expanded scope for 14 products such as electronic power supplies, room air conditioners and electric motors. These amendments will help us solidify Canada's position as an international leader in energy efficiency standards.

Under the Economic Action Plan, the Government of Canada expanded the ecoENERGY Retrofit - Homes program budget, resulting in an average energy savings of 22 percent per home and a reduction of three tonnes of greenhouse gas emissions per year, per home.

Energy efficiency is a key element of our Government's plan to fight climate change. The Government's plan will protect the environment and supports Canada's greenhouse gas emission reduction target of 17 percent below 2005 levels by 2020, a target that is aligned with that of the United States.

Canadians are making a conscious effort to improve their energy use. By investing in energy efficiency programs and promoting the use of clean energy by Canadian households and industry, we are creating high-quality jobs for Canadians and helping to protect our environment.

The Honourable Joe Oliver, P. C., M. P.
Minister of Natural Resources

Executive Summary

Canadians spent approximately $166 billion in 2007 on energy to heat and cool their homes and offices and to operate their appliances, cars and industrial processes. Several factors contribute to Canadian energy demand: a vast geography, a northern climate with extreme seasonal variations in temperature and an economy founded on an abundance of natural resources.

Types of Energy Use

The two general types of energy use are primary and secondary. Primary use represents Canada's total consumption, including energy required to transform one energy form to another – such as coal to electricity – and energy required to deliver energy to consumers. Secondary use is energy consumed for residential, commercial/institutional, industrial, transportation and agricultural purposes.

Key highlights in energy use include the following:

- Between 1990 and 2007, the latest year for which figures are available, secondary energy use increased by 28 percent.
- In 2007, secondary use accounted for 69 percent of primary energy use and produced 67 percent (501.6 megatonnes [Mt]) of Canada's total greenhouse gas (GHG) emissions. This last figure includes emissions produced by utilities in meeting the demand for electricity.
- Without the energy efficiency improvements made to buildings and equipment and the changes in the behaviour of energy users during the past several decades, the increases in energy use would have been 16 percent higher.

The industrial sector consumed the most energy, accounting for 39 percent of total secondary energy use in 2007. Transportation was second (29 percent), followed by residential (16 percent), commercial/institutional (13 percent) and agriculture (2 percent).

Promoting Energy Efficiency

Natural Resources Canada (NRCan) promotes energy efficiency and the use of alternative energy as a means to reduce GHG emissions and save money. NRCan uses a broad range of policy instruments, including leadership, information, voluntary initiatives, financial incentives, research and development, and regulation.

The *Energy Efficiency Act*, which came into force in 1992, provides for the making and enforcement of regulations concerning minimum energy performance levels for energy-using products, the labelling of energy-using products and the collection of data on energy use. The *Energy Efficiency Regulations* are described in Chapter 2.

Energy Intensity / Energy Efficiency

As explained in Chapter 1, although energy intensity is sometimes used as a proxy for energy efficiency, there is a difference between the terms. It is important to understand this difference when comparing Canada with other countries.

Energy efficiency refers to how effectively energy is being used for a given purpose. For example, providing a similar (or better) level of service with

less energy consumption on a per-unit basis is considered an improvement in energy efficiency.

Energy intensity is the amount of energy use per unit of activity. Examples of activity measures in this report are households, floor space, passenger-kilometres, tonne-kilometres, physical units of production and constant dollar value of gross domestic product. Energy intensity is a broader measure, capturing not only energy efficiency but also other impacts on energy consumption, such as weather variations, market behaviour and changes in the structure of the economy.

Evidence of Change

As explained in this report, recent growth in energy use is primarily due to increased activity in various sectors. However, this growth would have been much greater without improvements in energy efficiency.

As reported in Chapter 1, energy efficiency improvements made between 1990 and 2007 are estimated to have reduced GHG emissions by 63 Mt and saved Canadians $22.8 billion in 2007.

Between 1990 and 2007, the residential sector recorded a 29 percent improvement in energy efficiency. The figures for the transportation (22 percent), industrial (7 percent) and commercial/ institutional (16 percent) sectors demonstrate that improvements in energy efficiency are being made throughout the economy.

Through improvements in energy efficiency, Canadians can reduce their energy bills and achieve important environmental goals. Over the short term, changes to less GHG-intensive fuels (e.g. from coal to natural gas) can help reduce GHG emissions. However, over the long term, reducing GHG emissions further will require more widespread use of alternative energy.

Canada is a world leader in the production of renewable energy, with almost 16 percent of its primary energy supply coming from renewable energy sources in 2008.

Engaging Canadians

To maximize the effectiveness of its initiatives, NRCan engages a growing number of partners from the private and public sectors. Dozens of co-operative agreements are in place with a broad range of businesses, community groups and other levels of government.

These initiatives engage Canadian society, along with every sector of the economy, in new and more efficient approaches to secondary energy use and in the development and deployment of renewable energy sources.

This report provides an overview of the work being done in each sector and highlights NRCan's efficiency and alternative energy (EAE) programs and lists their key achievements for the 2009–2010 fiscal year. Program entries for market transformation programs also include quantitative performance indicators in graph or table format. A list of NRCan's EAE initiatives and expenditures appears in Appendix 1.

Although the period covered in this report is fiscal year 2009–2010, it is important to note that the Speech from the Throne 2010 and the Budget 2010 both contained references to the need to review the effectiveness of energy efficiency and clean energy programs. At the time of writing this report, the above-noted review is underway.

Introduction

NATURAL RESOURCES CANADA'S EFFICIENCY AND ALTERNATIVE ENERGY PROGRAMS

According to the International Energy Agency, if energy efficiency policies had not been introduced 30 years ago, today's worldwide energy consumption would be 50 percent higher.[1]

Gains in energy efficiency have substantial benefits for society, the economy and the environment. Energy efficiency can add to the global security of energy supplies by reducing the need for energy. It saves consumers and businesses money by decreasing their energy bills without disruptions to their daily routine, and it can increase access to energy services by reducing their effective cost. Energy efficiency also positively impacts economic competitiveness and employment.

In particular, greater energy efficiency is used as a strategy to reduce carbon dioxide and other greenhouse gases (GHGs) and thereby help reduce the effects of climate change.

Natural Resources Canada (NRCan) emphasizes the promotion of energy efficiency and the use of alternative energy (i.e. alternative transportation fuels and renewable energy) as ways to reduce GHG emissions and improve the Canadian economy.

A complete list of NRCan's efficiency and alternative energy (EAE) initiatives in 2009–2010 is in Appendix 1.

These initiatives engage Canadian society and all major sectors of the economy in new and more advanced approaches to secondary energy use – i.e. to the consumption of energy in the residential, commercial/institutional, industrial and transportation sectors.

NRCan's EAE initiatives are managed by the following:

- the Office of Energy Efficiency, which delivers market transformation initiatives to improve energy efficiency and the use of alternative transportation fuels
- CanmetENERGY and the CANMET Mineral Technology Branch, which deliver EAE research, development and demonstration (R,D&D) initiatives
- the Office of Energy Research and Development, which coordinates NRCan's energy research and development (R&D) planning and fund allocations
- the Electricity Resources Branch, which delivers market transformation initiatives for renewable energy
- the Science Branch of the Canadian Forest Service, which undertakes R&D in the use of forest biomass for energy
- the Policy, Economics and Industry branch of the Canadian Forest Service, which delivers funding for approved green capital projects in pulp and paper mills

In its efforts to improve energy efficiency and increase the use of alternative energy, NRCan emphasizes partnership and co-operation with stakeholders, such as other levels of government, the private sector and nongovernmental organizations.

With this approach, the demand side of the energy market moves toward more energy-efficient capital stock, production processes and operating

[1] International Energy Agency, *Mind the Gap: Quantifying Principal-Agent Problems in Energy Efficiency, 2007.*

practices without reducing service or comfort levels. On the supply side, Canada participates in developing technology for tapping renewable energy resources and alternative transportation fuels and in increasing the energy efficiency of energy production.

POLICY INSTRUMENTS

NRCan's key policy instruments are as follows:

- regulation
- financial incentives
- leadership
- information
- voluntary initiatives
- research, development and demonstration

Regulation

The *Energy Efficiency Act* gives the Government of Canada the authority to make and enforce regulations that prescribe standards and labelling requirements for energy-using products that are imported to Canada or shipped across provincial borders for lease or resale and prescribe standards for products that affect energy use.

Financial Incentives

NRCan uses financial incentives to encourage end-users of energy to adopt energy efficiency and renewable energy technologies and practices. NRCan also offers financial incentives for renewable power and heat, ethanol plants, energy efficiency and renewable energy production at pulp and paper mills, natural gas vehicles and refuelling infrastructure.

Leadership

Leadership means setting an example for other levels of government and for the private sector by increasing energy efficiency and the use of alternative energy in the Government of Canada's operations.

Information

NRCan disseminates information to consumers, using methods ranging from broad distribution to individual consultations with clients. This increases awareness of the environmental impact of energy use and encourages consumers to become more energy efficient and make greater use of alternative energy sources.

Information activities include publications, exhibits, advertising, toll-free telephone lines, conferences, Web sites, workshops, training, building-design software and promotional products. One particular outreach program targets youth as the energy consumers of the future and distributes activity booklets to virtually all elementary schools across the country.

Voluntary Initiatives

Companies and institutions work with NRCan voluntarily to set and achieve energy efficiency objectives. NRCan's voluntary EAE initiatives target the commercial/institutional and industrial sectors and organizations whose products are major factors in energy use. The initiatives involve industry-government agreements and, for groups of large industrial energy users, commitments to develop energy efficiency improvement targets and action plans. NRCan provides support to assist and stimulate action by companies and institutions on energy efficiency, including developing standards, educational material and training.

Research, Development and Demonstration

Ongoing improvement in energy efficiency is contingent on improvements and innovations in technology. NRCan's EAE initiatives support the development and dissemination of more energy-efficient equipment, processes and technologies and alternative energy technologies. R,D&D also provides the scientific knowledge needed to develop

the technologies, codes, standards and regulations required for the sustainable use of energy.

NRCan provides national leadership in energy science and technology (S&T) by undertaking research in its own laboratories and contracting research activities to other organizations. These initiatives are the only federal interdepartmental S&T investment funds that focus on the energy sector and its economic and environmental effects.

FIGURE INT-1

Moving the Market

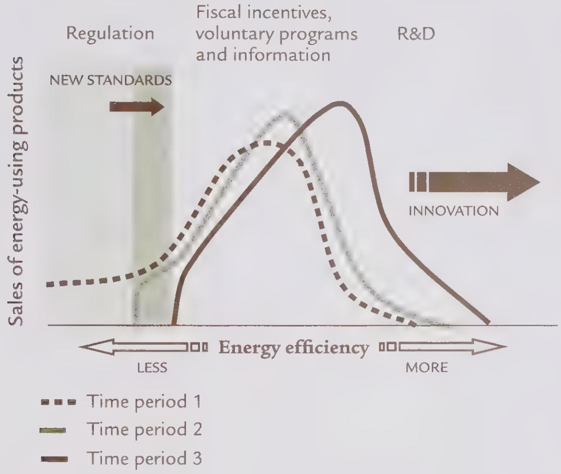


Figure INT-1 shows how these policy instruments work together to increase energy efficiency, that is, how they help to reduce the amount of energy required to complete a task or obtain a certain level of service. Energy performance regulations eliminate less efficient products from the market. Fiscal incentives, voluntary programs and information activities increase the number of people and organizations taking advantage of existing opportunities to use energy more efficiently. R&D increases the opportunities for achieving higher levels of efficiency in a particular type of energy use.

MEASURING PROGRESS

The primary goal of NRCan's EAE initiatives is to change energy consumption patterns and thereby generate environmental and economic benefits. Part of assessing program progress and performance involves considering both program delivery and program effectiveness. NRCan monitors and tracks the following three aspects of program delivery:

- program outputs
- program outcomes
- market outcomes

Program outputs are the items produced regularly, such as information and marketing materials, demonstration projects, financial incentives and regulations. Program outputs are designed to lead to **program outcomes** – namely, changes in the behaviour of groups targeted by a program. These groups may be either energy users or producers of energy-using equipment or structures. For example, program outcomes occur when consumers purchase more energy-efficient appliances than they would have if there were no program. Other important factors that influence consumer behaviour include product price, household income, personal taste and government and non-government programs.

Because program outcomes can directly affect the amount and type of energy consumed in the market, they contribute, in part, to observable **market outcomes**. Market outcomes ultimately reflect the impacts of NRCan programs on changes in energy efficiency, energy intensity, GHG emissions and the use of alternative energy. In this sense, achievement of a targeted market outcome, or observable progress toward a market outcome, may serve as an indicator of program effectiveness. Measuring progress toward an immediate market outcome can be difficult for R,D&D programs, which typically take many years to produce results that can be properly assessed.

An example of a program outcome leading to a market outcome is a householder's purchase of a more energy-efficient appliance, resulting in reduced use of electricity. Depending on what source of electricity is involved and how the utility changes its electricity-generating methods to meet the change in demand resulting from reduced electricity use, this could also lead to a decline in GHG emissions.

DATA COLLECTION AND ANALYSIS

In 1991, NRCan launched the National Energy Use Database (NEUD) initiative to help the Department improve its knowledge of energy consumption and energy efficiency at the end-use level in Canada and to support its analytical expertise. The NEUD initiative plays a number of crucial roles directly related to NRCan program activities. However, its most important role is to secure the development of a reliable, Canada-wide information base on energy consumption at the end-use level for all energy-consuming sectors.

The NEUD initiative consists of several broad components that typically involve conducting large- and small-scale surveys of energy use in the transportation, industrial, commercial/ institutional and residential sectors. The surveys gather information about the stocks and characteristics of energy-using equipment and buildings, observing Canadians' behaviour with respect to energy use and monitoring the adoption of new technologies in the marketplace.

In 2009–2010, analysis of the residential sector was undertaken for reference year 2007. This analysis forms the basis of reports explaining how and where energy is used in this sector (Survey of Household Energy Use [SHEU]). Data on the transportation sector continue to be collected on a quarterly basis, while industrial and commercial data continue to be collected annually.

The NEUD initiative also produces a comprehensive energy use database with accompanying publications to explain Canada's overall energy use and energy efficiency trends. All NEUD initiative reports are available to the public, free of charge, both in hard copy and online at oee.nrcan.gc.ca/statistics.

The NEUD initiative also contributes to the development of energy end-use data and analysis centres (DACs) across Canada. The DACs are mandated to improve the accessibility and comparability of existing data about trends in energy consumption and their impact on environmental quality, develop expert knowledge and advise on NEUD's data collection activities. Three DACs have been established:

- **transportation** at Université Laval in Québec, Quebec (Centre for Data and Analysis in Transportation [CDAT])
- **industrial** at Simon Fraser University in Burnaby, British Columbia (Canadian Industrial Energy End-Use Data and Analysis Centre [CIEEDAC])
- **buildings** at the University of Alberta in Edmonton, Alberta (Canadian Building Energy End-Use Data and Analysis Centre [CBEEDAC])

GHG EMISSIONS AND CLIMATE CHANGE

Climate change is a global challenge arising from the continuing buildup in levels of anthropogenic (human-produced) GHGs in the atmosphere in addition to naturally occurring emissions. GHGs are composed of several gases, and the main source of anthropogenic emissions is the combustion of fossil fuels. Substantially reducing GHG emissions is a challenge, particularly given Canada's highly industrialized and resource-based economy. Solutions require a multifaceted, coordinated domestic response and a high level of co-operation among all nations.

IN THIS REPORT

This seventeenth annual *Report to Parliament* focuses principally on EAE initiatives that address secondary energy use. Trends in energy use and GHG emissions in Canada for the residential, commercial, industrial, transportation and renewable energy sectors are discussed in Chapter 1.

Chapter 2 discusses equipment regulations under the *Energy Efficiency Act* and equipment-labelling activities. Chapter 3 describes the suite of ecoENERGY and related programs and lists key 2009–2010 achievements. Chapter 4 explains energy S&T programs and achievements related to energy efficiency and the continued integration of renewable sources. Chapter 5 outlines NRCan's involvement with renewable energy sources and use. The sixth and final chapter describes domestic and international co-operation in EAE.

Appendix 1 contains information about NRCan's EAE expenditures. Appendix 2 contains detailed information about the figure data presented in this report. Calculations of the estimated GHG savings in this report are based on Environment Canada's standardized emissions factors as described in its publication *Canada's Greenhouse Gas Inventory*. The emissions factor for electricity was based on the provincially weighted average of marginal fuel sources across the country.

CHAPTER 1

Trends in Energy Use

INTRODUCTION

Canadians enjoy an abundance of energy from a variety of sources. This comparative advantage in the supply of energy helps Canadians deal with the economic disadvantages of small domestic markets, long distances, rugged geography and a relatively harsh climate. It also fosters the development of industries with a particularly strong energy demand.

Canadians spent about $166 billion in 2007 on energy to heat and cool their homes and offices and to operate their appliances, vehicles and industrial processes. This amount is equivalent to almost 12 percent of the country's gross domestic product (GDP).[2]

ENERGY USE AND GREENHOUSE GAS EMISSIONS

Energy use is of two general types: primary and secondary. Primary energy use encompasses the total requirements for all users of energy, the energy required to transform one energy form to another (e.g. coal to electricity) and the energy used to bring energy supplies to the consumer. Secondary energy use is energy used by final consumers for residential, commercial/institutional, industrial, transportation and agricultural purposes.

Primary energy use represents the total requirements for all users of energy, including secondary energy use. In Canada, the increase in primary energy use reflects changes over several decades in energy-consuming equipment and buildings and in the behaviour of energy users. Primary energy use was 12 786 petajoules[3] (PJ) in 2007.

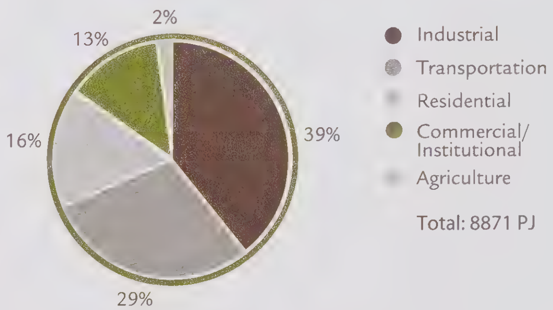
Secondary energy use accounted for 69 percent of primary energy use in 2007, or 8870.5 PJ. It was responsible for 67 percent (501.6 megatonnes [Mt]) of total greenhouse gas (GHG) emissions in Canada, including indirect emissions – those produced by electric utilities to meet end-use electrical demand.

From 1990 to 2007, secondary energy use increased by 28 percent, the Canadian population grew 19 percent, and the GDP increased 58 percent. Thus energy use grew less rapidly than the economy but more rapidly than the population.

As demonstrated in Figure 1-1, the industrial sector was the largest energy user, accounting for 39 percent of total secondary energy use in 2007. The transportation sector was the second largest energy user at 29 percent, followed by the residential sector at 16 percent, the commercial/institutional sector at 13 percent and the agricultural sector at 2 percent.

FIGURE 1-1

Secondary Energy Use by Sector, 2007



Source: oee.nrcan.gc.ca/corporate/statistics/neud/dpa/handbook_tables.cfm?attr=0

Figure 1-2 illustrates the distribution of GHG emissions by sector. This report deals with energy-related GHG emissions, which comprise carbon dioxide (CO_2), methane and nitrous oxide. CO_2 accounts for most of Canada's GHG emissions. All subsequent references in this report to CO_2 and GHGs include emissions that are attributable

---

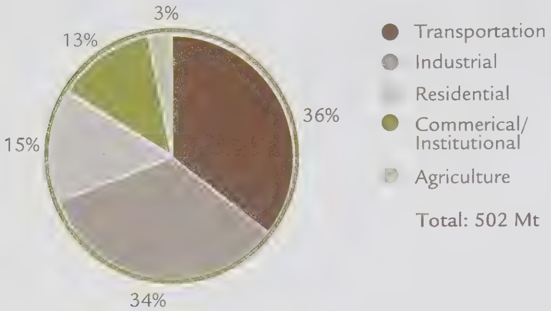
[2] Data in this chapter are presented for 1990–2007. Readers are encouraged to consult the Office of Energy Efficiency Web site to view data updates as they become available.

[3] One petajoule equals 1×10^{15} joules.

directly to secondary energy use and emissions that are attributable indirectly to electricity generation, unless otherwise specified.

FIGURE 1-2

GHG Emissions From Secondary Energy Use by Sector, 2007



Source: oee.nrcan.gc.ca/corporate/statistics/neud/dpa/

ENERGY INTENSITY AND ENERGY EFFICIENCY

The term "energy intensity" refers to the amount of energy use per unit of activity. Energy intensity is sometimes used as a proxy for energy efficiency because it is a simple calculation for which data are readily available. However, this measure can be misleading because, in addition to pure energy efficiency, intensity captures the impact of other factors that influence energy demand, such as weather variations and changes in the structure of the economy.

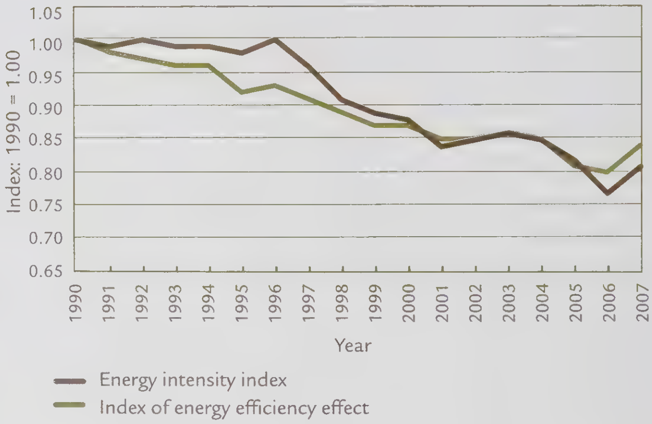
Energy efficiency refers to how effectively energy is being used for a given purpose. For example, providing a similar (or better) level of service with less energy consumption on a per-unit basis is considered an improvement in energy efficiency.

To properly gauge changes in energy efficiency over time, differences in economic structure and weather need to be normalized or factored out of the intensity calculation. Natural Resources Canada's (NRCan's) Office of Energy Efficiency (OEE) applies an internationally recognized factorization analysis technique – the Log-Mean Divisia Index I methodology – to isolate the impact of energy efficiency on changes in Canadian energy use.

Figure 1-3 compares, for Canada, an index of annual variation in energy intensity with the OEE's index of changes in energy efficiency from 1990 to 2007. As illustrated, Canada's energy intensity and efficiency improved over this period. The reduction in energy intensity reflects an overall improvement in energy efficiency or how effectively energy is being used in producing one unit of GDP. At the same time, the improvement in energy efficiency indicates how effectively energy is being used to provide a certain level of service or output.

FIGURE 1-3

Energy Intensity and the Energy Efficiency Effect, 1990 to 2007



Source: Natural Resources Canada, Residential, Commercial/Institutional, Transportation, Industrial End-Use Models, Ottawa, 2009.

As illustrated in Figure 1-3, intensity underestimates the efficiency effect in Canada in the early 1990s and overestimates its impact in the latter part of the period. Before 1998, intensity improvements appear to be modest because colder weather (1992–1997) and a shift toward more energy-intensive industries (1990–1996) masked energy efficiency progress. In 2000, the intensity index dipped below the index for the energy efficiency effect. A switch to less energy-intensive industries, which began in the mid-1990s, combined with energy efficiency improvements accelerated the decline in energy intensity.

TRENDS IN ENERGY EFFICIENCY

NRCan regularly publishes *Energy Efficiency Trends in Canada*, which reports on changes in energy use and GHG emissions and the contributions of the following key factors to these changes (see Table 1-1):

- Increases in sector **activity** lead to increased energy use and GHG emissions. Activity is defined differently in each sector. For example, in the residential sector, it is defined as the number of households and the floor space of residences. In the industrial sector, it is defined as industrial GDP, gross output and physical industrial output, such as tonnes of steel.
- Fluctuations in **weather** lead to changes in space-heating and space-cooling requirements. A colder winter or a warmer summer can lead to increased energy use.
- A shift in the **structure** of activity toward more energy-intensive components of activity leads to increased energy use and emissions. For example, if the distribution of activity in the industrial sector shifts from forestry to the iron and steel industry, industrial energy use will increase because the former sector is less energy intensive than the latter.
- **Service level** refers to the penetration rate of electrical devices and equipment, for example, the use of auxiliary equipment in commercial/institutional buildings and appliances in homes or the amount of floor space cooled.
- **Energy efficiency** effect indicates how effectively energy is being used, for example, the degree to which less energy is being used to provide the same level of energy service. Energy efficiency gains occur primarily with improvements in technology or processes. An example of such an improvement would be replacing incandescent lights with compact fluorescent lamps.

In this report, changes in energy efficiency are the net result after allowing for changes in energy use

TABLE 1-1

Explanation of Changes in Secondary Energy Use, 1990 to 2007

	Sectors					
	Residential	Commercial/ Institutional	Industrial	Transportation	Total*	Change (%)
1990 energy use (PJ)	1282.3	867.0	2710.0	1877.9	6936.3	
2007 energy use (PJ)	1447.2	1141.6	3471.6	2595.2	8870.5	
Change in energy use (PJ)	164.9	274.6	761.6	717.3	1934.2	27.9
Source: oee.nrcan.gc.ca/corporate/statistics/neud/dpa/handbook_tables.cfm?attr=0						
Explanatory factor (change due to)						
Activity	456.4	294.7	1261.7	853.8	2866.6	41.3
Weather	15.0	15.2	n/a	n/a	30.2	0.4
Structure	0.6	0.3	-315.3	218.5	-95.8	-1.4
Service level	71.1	103.6	n/a	n/a	174.7	2.5
Energy efficiency	-378.2	-138.7	-184.8	-388.0	-1089.7	-15.7
Other factors		-0.5			48.3	0.7

Source: oee.nrcan.gc.ca/corporate/statistics/neud/dpa/analysis_ca.cfm?attr=0

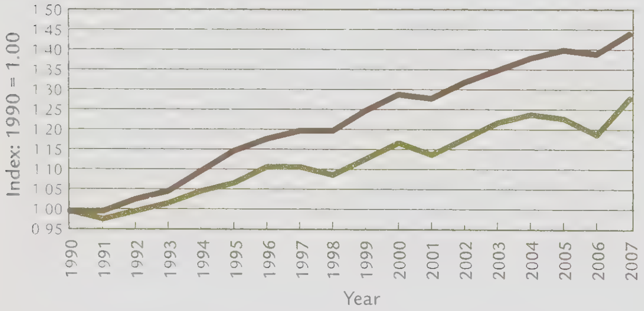
*Total also includes energy use for agriculture.

due to activity, weather, structure and service level. However, other factors, such as individual consumer choice, may affect energy use and are not captured by the above standardized factors. The effects of activity, weather, structure and service level may overstate or understate the "actual" change in energy use and energy efficiency improvements.

Between 1990 and 2007, secondary energy use in Canada increased from 6936.3 to 8870.5 PJ. Without improvements in energy efficiency, increases attributable to activity, weather, structure and service level would have led to an energy increase of 44 percent. However, as a result of a 16 percent (1090 PJ) improvement in energy efficiency,[4] actual secondary energy use increased by only 28 percent (to 8870.5 PJ). This improvement in energy efficiency is estimated to have reduced GHG emissions by 63 Mt and decreased energy expenditures by $22.8 billion in 2007. The change in energy use between 1990 and 2007, actual and without energy efficiency improvements, is shown in Figure 1-4.

FIGURE 1-4

Secondary Energy Use, Actual and Without Energy Efficiency Improvements, 1990 to 2007



Source: oee.nrcan.gc.ca/corporate/statistics/neud/dpa/analysis_ca.cfm?attr=0

TRENDS IN RENEWABLE ENERGY

Canada is a leader in the production of renewable energy, with over 16 percent of its primary energy supply coming from renewable energy sources in 2008. Although renewable energy is often associated with electricity, renewable energy sources also produce thermal energy (heat) and transportation fuels. Renewable energy sources in Canada include inland and ocean water, wind, solar, geothermal and biomass.

Canada has a significant renewable electricity supply due primarily to the widespread use of hydroelectricity. In 2008, 60.4 percent of Canada's electricity generation was provided by conventional and small hydroelectric plants, which generated more than 376 terawatt hours (TWh) of electricity, up 3.3 percent from 364 TWh in 2007. Small hydro plants (less than 50 megawatts [MW]), with installed generating capacity of 3452 MW, provided about 2 percent of the total electricity generation in Canada.

Several provinces are taking steps to support the development of the next generation of ocean renewable energy technologies, which use waves, ocean currents and tides to generate electricity.

In 2010, the Fundy Ocean Resource Centre for Energy, a technology demonstration facility, started testing three technologies with a total capacity of 4 MW. Wave and tidal-current technologies are also being tested off the coast of British Columbia, and a commercial facility for generating electricity may be feasible within the next decade.

Although technical, regulatory and financial challenges remain, ocean energy has the potential to provide Canada with an abundant source of renewable energy.

Non-hydro renewable sources accounted for an estimated 2 percent of Canada's electricity generation. With 1516 MW of installed capacity in 2008, biomass (waste and virgin biomass and

[4] Based on the OEE Index.

landfill gas) is one of the main non-hydro renewable energy sources in Canada.

Wind energy is growing rapidly, with an increase in capacity from 139 MW in 2000 to 3319 MW in 2009. Wind power may soon be moving to the offshore, with large projects planned on submerged lands off the coast of British Columbia and in the Great Lakes.

Solar photovoltaic (PV) energy also experienced high rates of capacity growth – about 32 percent average growth rate annually between 1992 and 2009 – although it started from a very low baseline. 2009 was the best year so far for solar PV, with approximately 95 MW of solar PV systems installed in Canada, representing an increase of 62 MW from the previous year.

The Canadian active solar thermal installed capacity in 2008 was 720 000 square metres (m^2), which is approximately 500 megawatts thermal (MW_{th}). The domestic market increase has averaged 13 percent annually since 1998. In 2008, the solar thermal collector market in Canada was 139 159 m^2, more than twice the installations in 2007 (60 900 m^2), with revenues up 44 percent from 2007.

In 2008, 15 000 ground-source heat pumps (GSHP) units were installed in Canada. This is a large increase from the 9100 units installed in 2007 and 4217 units installed in 2006. As of December 31, 2009, there were approximately 46 000 GSHPs with 555 MW_{th} of installed capacity producing an estimated 760 gigawatt-hours equivalent annually.

As described in Chapter 5, NRCan is carrying out three initiatives – ecoENERGY for Renewable Power, ecoENERGY for Renewable Heat and the Pulp and Paper Green Transformation Program – to increase the use of renewable energy in Canada.

TRENDS IN RESIDENTIAL SECTOR

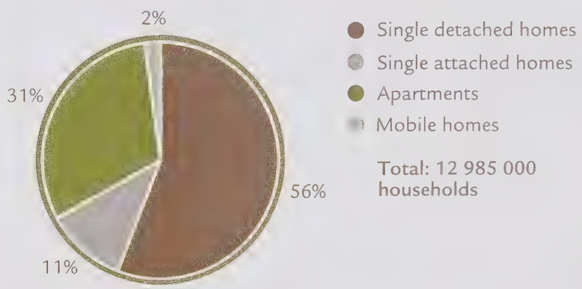
Energy Use and Greenhouse Gas Emissions

The residential sector includes four major types of dwellings: single detached, single attached, apartments and mobile homes. Energy is used in dwellings for space heating and cooling; water heating; and the operation of appliances, electronic equipment and lights. In 2007, this sector accounted for 16 percent (1447.2 PJ) of secondary energy use and 15 percent (74.3 Mt) of GHGs emitted in Canada.

Most dwellings in Canada are single detached houses. The next largest type of dwelling is apartments, followed by single attached dwellings and mobile homes (see Figure 1-5). The OEE's ecoENERGY Retrofit – Homes and ecoENERGY for Buildings and Houses programs aim to improve the energy efficiency of single detached and attached houses.

FIGURE 1-5

Canadian Households by Type of Dwelling, 2007



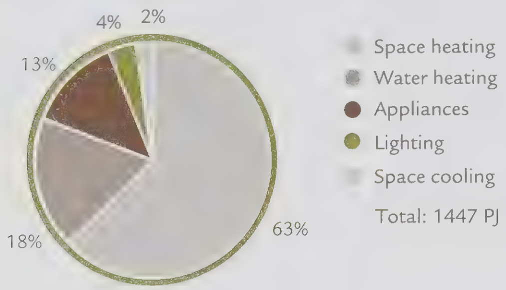
Source: oee.nrcan.gc.ca/corporate/statistics/neud/dpa/handbook_res_ca.cfm?attr=0

Between 1990 and 2007, residential energy use increased by 13 percent, or 164.9 PJ. For the same period , GHG emissions increased by 11 percent.

GHG intensity decreased 2 percent despite the average household operating more appliances, becoming larger and increasing its use of space cooling. Space and water heating constituted 81 percent of residential energy use (which exhibited a small drop in space-heating energy use), followed by operating appliances, lighting and space cooling (see Figure 1-6).

FIGURE 1-6

Residential Energy Use by End Use, 2007



Source: oee.nrcan.gc.ca/corporate/statistics/neud/dpa/handbook_res_ca.cfm?attr=0

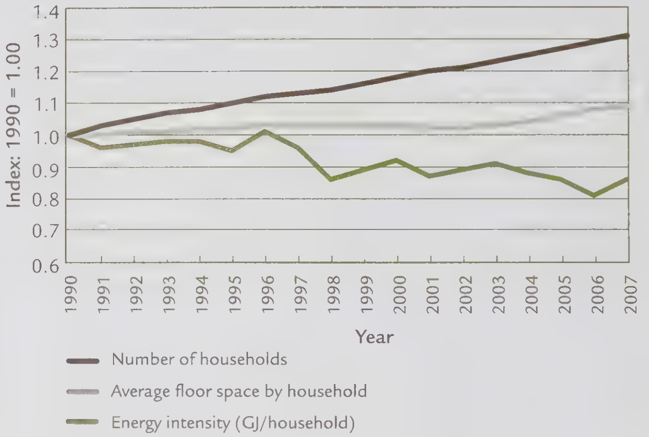
Five main factors influenced residential energy use between 1990 and 2007 – activity, weather, structure, service level and energy efficiency effect:

- Activity – As measured by combining a mix of households and floor space, energy use increased 36 percent (456.4 PJ). Growth in activity was driven by a 44 percent increase in floor area and by a rise of 31 percent in the number of households.
- Weather – In 2007, winter temperatures were similar to those of 1990 but the summer was warmer. The net result was an overall increase in energy demand for temperature control of 15.0 PJ.
- Structure – The increase in the relative share of households by dwelling type resulted in the sector using an additional 0.6 PJ of energy.
- Service level – The increased penetration rate of appliances and the increased floor space cooled by space cooling units were responsible for 71.1 PJ of the increase in energy.
- Energy efficiency – Improvements to the thermal envelope of houses and to the efficiency of residential appliances and space-and water-heating equipment led to an overall energy efficiency gain in the residential sector. This efficiency gain saved 378.2 PJ of energy.

Growth in residential energy use was driven in large part by growth in activity. This growth in activity – specifically, growth in total floor space and number of households – was due to the increase in the average size of newly constructed houses, the rising population and the trend toward fewer individuals per household (see Figure 1-7).

FIGURE 1-7

Number of Households, Average Floor Space by Household and Energy Intensity Indexes, 1990 to 2007



Source: oee.nrcan.gc.ca/corporate/statistics/neud/dpa/analysis_ca.cfm?attr=0

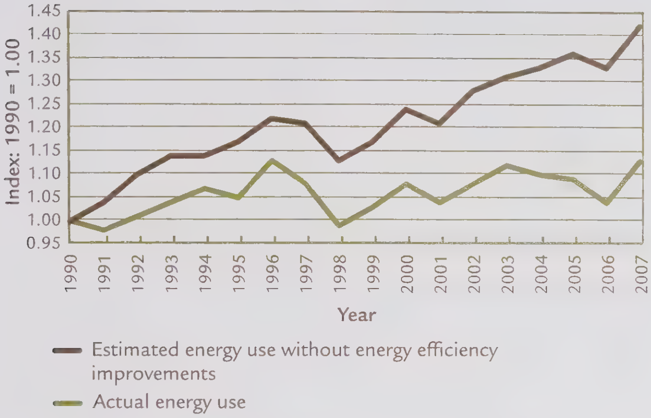
These increases were partially offset by significant improvements in energy efficiency. Service level increased energy demand because more Canadians cooled their homes during the summer months in 2007 than in 1990, and Canadians operated more appliances in 2007 than they did in 1990.

Energy Efficiency

The change in residential energy use between 1990 and 2007 and the estimated energy savings due to energy efficiency measures are shown in Figure 1-8.

FIGURE 1-8

Residential Energy Use, Actual and Without Energy Efficiency Improvements, 1990 to 2007



Source: Natural Resources Canada, Residential End-Use Model, Ottawa, 2009.

Overall, energy efficiency upgrades – including improvements to the thermal envelope (insulations, windows, etc.) and more energy-efficient appliances, furnaces and lighting – resulted in significant monetary savings for each Canadian household.

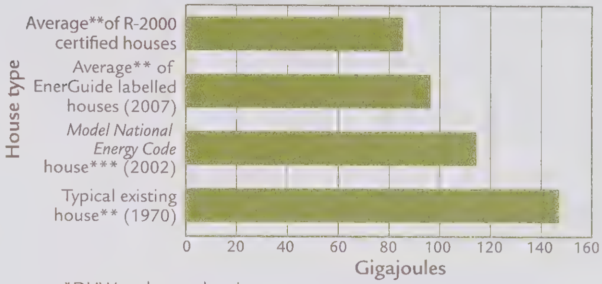
The 29 percent improvement in energy efficiency between 1990 and 2007 translated into $7.4 billion in energy savings in 2007.

Figure 1-9 shows how energy consumption differs for houses built in different periods, reflecting improvements in building construction.

Figure 1-10 shows how average energy consumption of new appliances has improved, by comparing 1990 and 2007 models.

FIGURE 1-9

Annual Heating* Consumption for Houses Constructed to Different Standards



*DHW and space heating

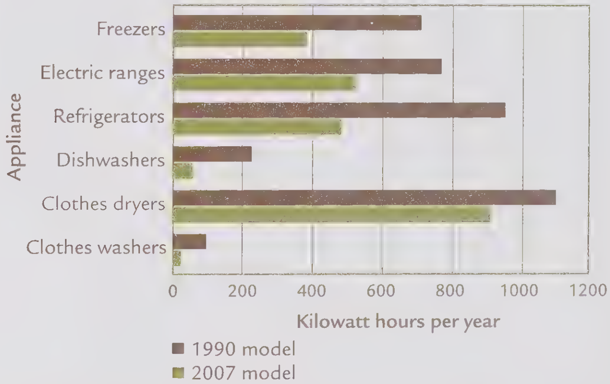
**National average

***198-m², two-storey, single detached house heated with natural gas located in Ottawa, Ontario

Source: NRCan national housing database and internal data.

FIGURE 1-10

Average Energy Consumption of New Electric Appliances, 1990 and 2007 Models



Source: Natural Resources Canada, Residential End-Use Model, Ottawa, 2009.

NRCan carries out the following initiatives to increase energy efficiency in the residential sector:

- ecoENERGY Retrofit – Homes
- ecoENERGY for Buildings and Houses
- Clean Energy Systems for Buildings and Communities
- ecoENERGY for Equipment (see Chapter 2)

TRENDS IN COMMERCIAL/ INSTITUTIONAL SECTOR

Energy Use and Greenhouse Gas Emissions

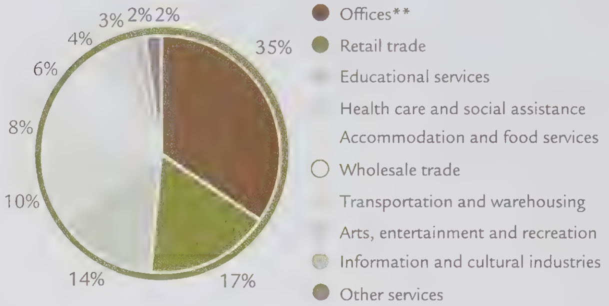
The commercial/institutional sector includes activity related to trade, finance, real estate, public administration, education and commercial services, including tourism. This sector uses energy mainly for space and water heating, operation of auxiliary equipment, space cooling, lighting, motive power for such services as pumping and ventilation in buildings, and street lighting.

In 2007, the commercial/institutional sector accounted for 13 percent (1142 PJ) of secondary energy use and GHG emissions in Canada. Between 1990 and 2007, commercial/institutional energy use (including street lighting) increased by 32 percent, or 275 PJ. GHG emissions from the sector rose by 36 percent in the same period. The increase in use of GHG-intensive fuels, such as heavy oil and light fuel oil, explains why GHG emissions grew at a faster pace than energy use.

To highlight energy use in commercial/institutional activities, the following analysis excludes energy use for street lighting. The commercial/institutional sector comprises many activity types (see Figure 1-11). In 2007, offices accounted for 35 percent of the sector's energy demand. Retail trade, educational services, health care and social assistance, and accommodation and food services accounted for another 49 percent of that demand.

FIGURE 1-11

Commercial/Institutional Energy Use by Activity Type,* 2007



* Excludes street lighting.

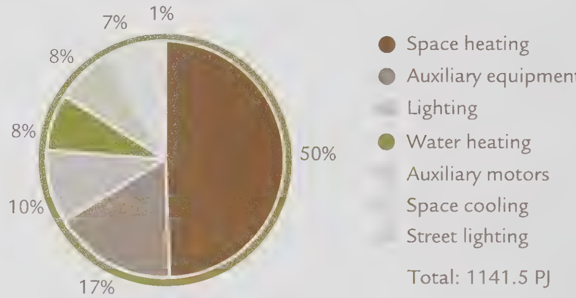
**"Offices" includes activities related to finance and insurance; real estate and rental and leasing; professional, scientific and technical services; and public administration.

Source: oee.nrcan.gc.ca/corporate/statistics/neud/dpa/handbook_com_ca.cfm?attr=0

Energy is used for seven purposes in commercial/institutional activities. As illustrated in Figure 1-12, in 2007, the largest of these was space heating, which accounted for half of the energy use in the sector. The remaining six uses of energy accounted for between 1 percent and 17 percent of energy demand in the sector.

FIGURE 1-12

Commercial/Institutional Energy Use by Purpose, 2007



Source: oee.nrcan.gc.ca/corporate/statistics/neud/dpa/handbook__com_ca.cfm?attr=0

Five main factors influenced commercial/institutional energy use between 1990 and 2007 – activity, weather, structure, service level and energy efficiency effect:

- Activity – An increase in floor space raised energy use by 34 percent (294.7 PJ) and increased GHG-related emissions by 16.7 Mt.
- Structure – The effect of structure changes in the sector (the mix of activity types) was small and therefore changed GHG-related emissions only marginally.
- Weather – The winter of 2007 was similar to the winter of 1990, but the summer was warmer. The net result was a 15.2-PJ increase in energy demand in the commercial/institutional sector, mainly for space conditioning, which had the effect of increasing GHG-related emissions by 0.9 Mt.
- Service level – An increase in space cooling and in the service level of auxiliary equipment, which is the penetration rates of office equipment (e.g. computers, fax machines and photocopiers), led to a 103.6-PJ increase in energy use and a 5.9-Mt increase in GHG-related emissions.
- Energy efficiency – Improvements in the energy efficiency of the commercial/institutional sector saved 138.7 PJ of energy and 7.8 Mt of related emissions.

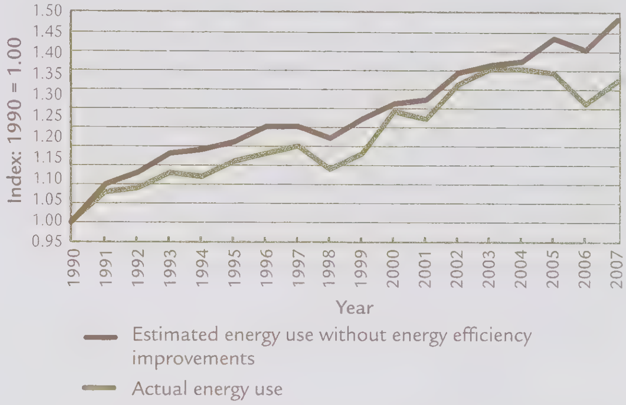
Energy Efficiency

Gains in energy efficiency were made through improvements to the thermal envelope of buildings (insulation, windows, etc.) and increased efficiency of energy-consuming items, such as furnaces, auxiliary equipment and lighting, which slowed the rate of increase in energy use. Without improvements in energy efficiency, energy use in the commercial/institutional sector would have increased by 48 percent. However, actual energy use increased by only 32 percent between 1990 and 2007, resulting in energy savings of $2.9 billion in 2007.

The change in energy use between 1990 and 2007, as well as the estimated energy savings due to improvements in energy efficiency, are shown in Figure 1-13.

FIGURE 1-13

Commercial/Institutional Energy Use, Actual and Without Energy Efficiency Improvements, 1990 to 2007



Source: Natural Resources Canada, Commercial/Institutional End-Use Model, Ottawa, 2009.

NRCan carries out the following initiatives to increase energy efficiency in the commercial/institutional sector:

- ecoENERGY Retrofit – Small and Medium Organizations
- ecoENERGY for Buildings and Houses
- Clean Energy Systems for Buildings and Communities
- ecoENERGY for Equipment (see Chapter 2)

TRENDS IN INDUSTRIAL SECTOR

Energy Use and Greenhouse Gas Emissions

The industrial sector includes all manufacturing industries, all mining activities (including oil and gas extraction), forestry and construction. However, it excludes electricity generation. This sector uses energy in industrial processes as a source of motive power and to produce heat or generate steam.

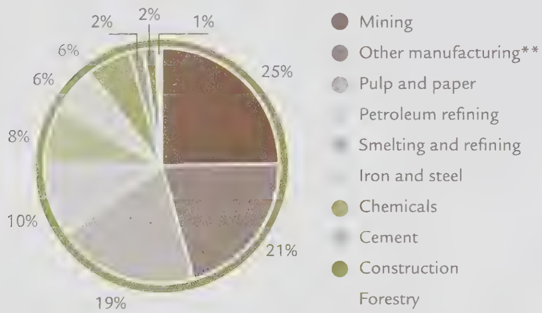
Overall, industrial energy demand in 2007 accounted for 39 percent (3472 PJ) of secondary

energy use and 34 percent (169 Mt) of GHG emissions (including electricity-related emissions). Between 1990 and 2007, actual industrial energy use increased by 28 percent (762 PJ). This increase was caused by the increase in industrial activity, measured as a combination of physical units of production, gross output and GDP.

In the industrial sector, energy was consumed primarily in mining, other manufacturing, pulp and paper production, and the petroleum refining industries. Mining alone accounted for 25 percent of total industrial energy demand in 2007 (see Figure 1-14).

FIGURE 1-14

Industrial Energy Use by Subsector – Including Electricity-Related Emissions,* 2007



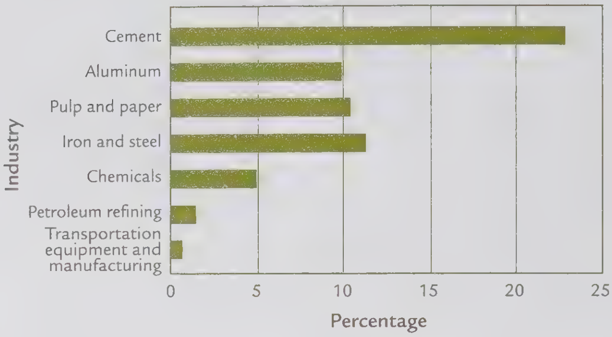
*The above subsectors reflect the current definitions in the *Report on Energy Supply and Demand in Canada*.
**"Other manufacturing" comprises more than 20 manufacturing industries.

Source: oee.nrcan.gc.ca/corporate/statistics/neud/dpa/trends_agg_ca.cfm

In most industries, energy purchases accounted for only a small portion of total expenditures. However, for some relatively energy-intensive industries – cement, aluminium, pulp and paper, and iron and steel – this share was 10 percent or higher (see Figure 1-15). For cement, in particular, the share was 23 percent.

FIGURE 1-15

Cost of Energy to Manufacturing Industries as a Percentage of Total Production Cost, 2007



Source: Statistics Canada, CANSIM Table 301-0006.

Between 1990 and 2007, industrial GHG emissions, including electricity-related emissions, increased by 24 percent. Excluding electricity-related emissions, industrial GHG emissions increased by 19 percent. Most of this increase in direct GHG emissions occurred in the upstream oil and gas industry. The pulp and paper industry, however, achieved a 28 percent decrease in GHG emissions.

Three main factors influenced industrial energy use between 1990 and 2007 – activity, structure and energy efficiency effect:

- Activity – The mix of GDP, gross output and production units (activity measures) increased the energy use by 75 percent, or 1261.7 PJ.
- Structure – The structural changes in the industrial sector, specifically a relative decrease in the activity share of energy-intensive industries, helped the sector reduce its energy use by 315.3 PJ. Note that industries consuming more than 6 megajoules [5] per dollar of GDP (e.g. pulp and paper, petroleum refining, upstream mining) represented 28 percent of industrial GDP in 1990. They accounted for 25 percent in 2007.
- Energy efficiency – Improvements in the energy efficiency of the industrial sector avoided 184.8 PJ of energy use.

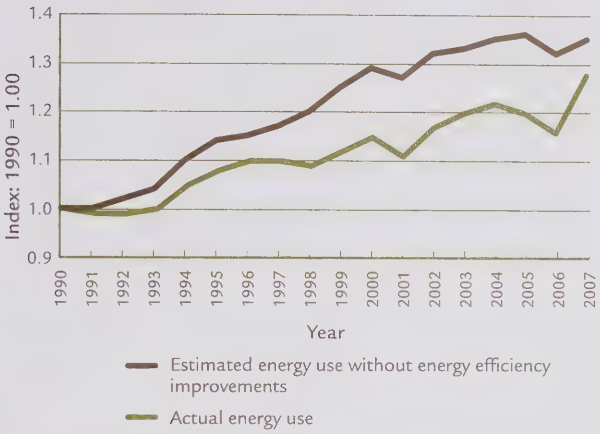
[5] One megajoule equals 1×10^6 joules.

Energy Efficiency

The change in energy use between 1990 and 2007 and the estimated energy savings attributed to energy efficiency are shown in Figure 1-16.

FIGURE 1-16

Industrial Energy Use, Actual and Without Energy Efficiency Improvements, 1990 to 2007



Source: Natural Resources Canada, Industrial End-Use Models, Ottawa, 2009.

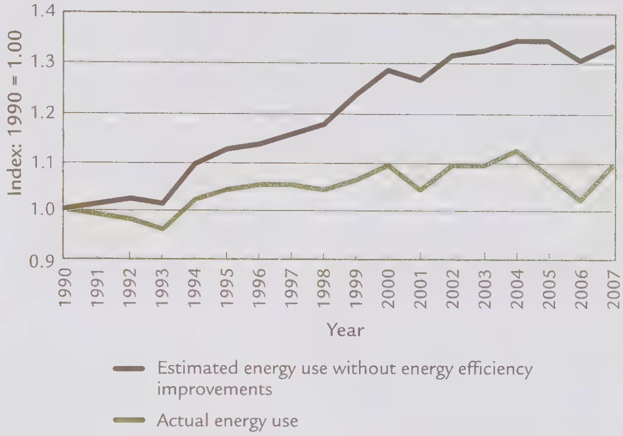
Energy efficiency improvements in the form of more efficient capital and management practices are important factors in managing energy use and decreasing energy intensity.

Between 1990 and 2007, energy efficiency in the industrial sector improved 7 percent. In 2007, Canadian industry saved $2.1 billion in energy costs. This gain was largely the result of improvements in energy intensity, representing the shift toward less energy-intensive activities. However, energy savings from the energy efficiency improvements made by some industries were offset by increases in consumption by the upstream oil and gas, fertilizer and forestry subsectors.

From 1990 to 2007, the upstream mining share of industrial energy use grew from 8 percent to 22 percent. This change reflects not only growth in production but also a shift from conventional to the significantly more energy-intensive unconventional oil production. Netting out the upstream mining, Canadian industries improved energy efficiency by 23 percent, which represents 617.7 PJ of savings (see Figure 1-17) and corresponds to $7 billion in avoided energy costs.

FIGURE 1-17

Industrial Energy Use, With and Without Energy Efficiency Improvements (Without Upstream Mining), 1990 to 2007



Source: Natural Resources Canada, Industrial End-Use Model, Ottawa, 2009.

NRCan carries out the following initiatives to increase energy efficiency in the industrial sector:

- ecoENERGY Retrofit – Small and Medium Organizations
- ecoENERGY for Industry
- Clean Energy Systems for Industry
- ecoENERGY for Equipment (see Chapter 2)

TRENDS IN TRANSPORTATION

Energy Use and Greenhouse Gas Emissions

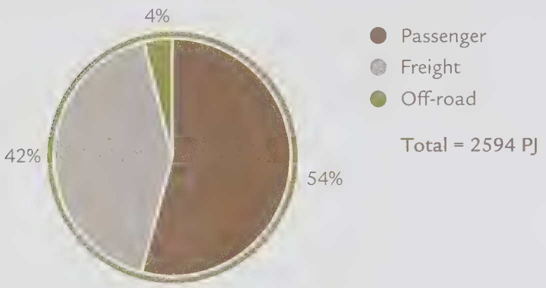
In 2007, transportation was second to the industrial sector in terms of energy use, accounting for 29 percent (2595 PJ) of Canada's total secondary energy use and the largest portion of Canadian end-use GHG emissions at 36 percent (179.4 Mt).

Transportation accounts for a greater share of GHG emissions because the main fuels used by the sector are more GHG-intensive than those used in other sectors of the economy.

The transportation sector consists of three subsectors: passenger, freight and off-road. In 2007, passenger and freight transportation accounted for 54 percent and 42 percent of transportation energy use respectively, while off-road represented only 4 percent (see Figure 1-18). Owing to limitations in the available data and the small percentage it accounts for, the off-road subsector is not analysed in further detail.

FIGURE 1-18

Transportation Energy Use by Mode, 2007



Source: oee.nrcan.gc.ca/corporate/statistics/neud/dpa/handbook_tran_ca.cfm?attr=0

The passenger subsector has three modes: road, rail and air. The freight subsector, as defined by NRCan, is composed of road, rail, air and marine modes. All of NRCan's transportation energy use programs focus on the energy used in road transportation. Total transportation energy use increased by 38 percent (717 PJ) between 1990 and 2007. Within the transportation sector, passenger transportation energy use increased by 19 percent (228 PJ), while freight transportation energy use increased by 70 percent (445 PJ).

Three main factors influenced passenger transportation energy use between 1990 and 2007 – activity, structure and energy efficiency effect:

- Activity – The activity effect (i.e. passenger-kilometres [Pkm] travelled) increased energy use by 38 percent, or 433.2 PJ, with a corresponding 29.4-Mt increase in GHG emissions. Light truck and air transportation led the growth in Pkm (and therefore, activity effect), with respective increases of 165 percent and 89 percent.
- Structure – Changes to the mix of transportation modes, or the relative share of Pkm travelled by air, rail and road, are used to measure changes in structure. The popularity of minivans and sport utility vehicles (SUVs) increased the activity share of light trucks compared with other modes, contributing to a 33.8-PJ increase in energy consumption and a 2.3-Mt increase in GHG emissions.
- Energy efficiency – Improvements in the energy efficiency of passenger transportation saved 227.9 PJ of energy and 15.5 Mt of energy-related GHG emissions. Despite the increasing popularity of larger and heavier light-duty vehicles with greater horsepower, the light-duty vehicle segment (cars, light trucks and motorcycles) of passenger transportation was able to show 172.5 PJ of energy savings.

Three main factors influenced freight transportation energy use between 1990 and 2007 – activity, structure and energy efficiency effect:

- Activity – The activity effect (i.e. tonne-kilometres moved) increased energy use 66 percent, or 420.6 PJ, and caused a corresponding 29.8-Mt increase in GHG emissions. This increase was influenced by greater international trade and the deregulation of the trucking and rail industries.

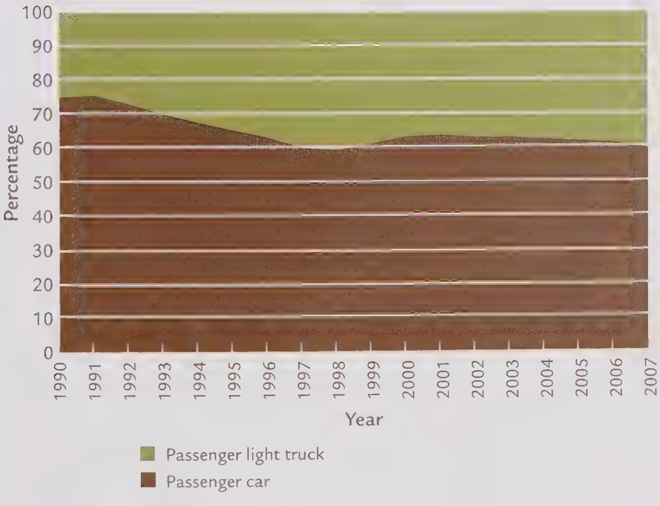
- Structure – Changes in the structure of freight transportation (shifts in activity between modes) stemmed from growth in international trade and customer requirements for just-in-time delivery. The shift between modes was the increase in the share of freight moved by heavy trucks relative to other modes. Because trucks are more energy intensive per tonne-kilometre than other modes, the sector used an additional 184.8 PJ of energy and emitted 13.1 Mt more GHG emissions.

- Energy efficiency – Improvements in the energy efficiency of freight transportation saved 160.1 PJ of energy and 11.3 Mt of GHG emissions. Improvements in freight trucks were a large contributor, saving 101.1 PJ.

Figure 1-19 shows how the market share of new light trucks increased in the 1990s, reflecting the increase in popularity of minivans and SUVs. Recently, however, this trend seems to have stabilized, with the share of light trucks remaining steady over the past few years. The higher share of heavier and more powerful passenger vehicles has had a significant effect on the increase in passenger energy use.

FIGURE 1-19

Market Shares of New Passenger Car and Light-Truck Sales, 1990 to 2007



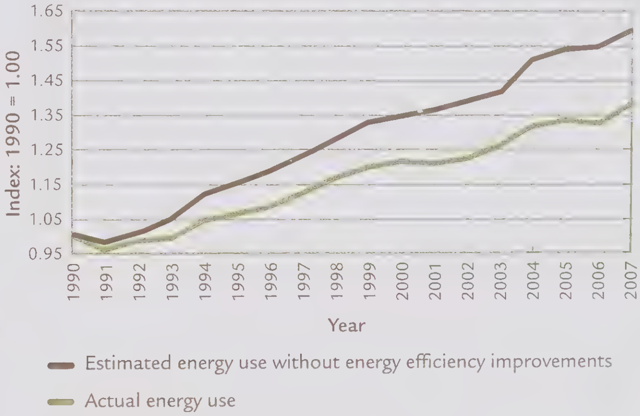
Source: oee.nrcan.gc.ca/corporate/statistics/neud/dpa/handbook_tran_ca.cfm?attr=0

Energy Efficiency

Without improvements in energy efficiency, increases attributable to activity and structure would have led to an increase in transportation energy use of 59 percent. However, between 1990 and 2007, actual energy use increased by 38 percent. During this period, energy efficiency in the transportation sector improved by 22 percent, leading to a savings of $10.3 billion in 2007. This change in energy use between 1990 and 2007 and the estimated energy savings due to energy efficiency improvements are shown in Figure 1-20.

FIGURE 1-20

Transportation Energy Use, Actual and Without Energy Efficiency Improvements, 1990 to 2007

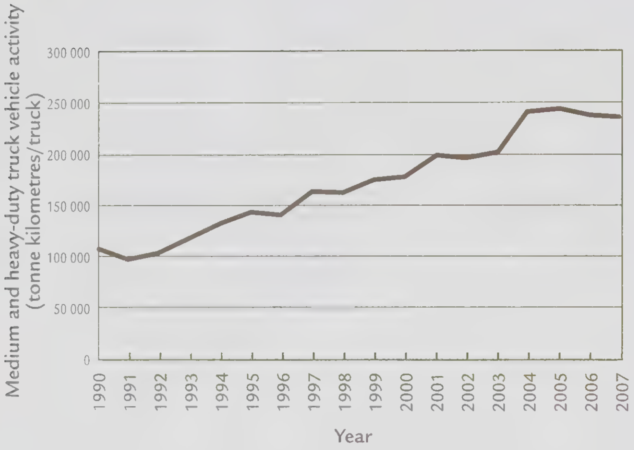


Source: oee.nrcan.gc.ca/corporate/statistics/neud/dpa/handbook_tran_ca.cfm?attr=0

Figures 1-21 and 1-22 illustrate an improvement in trucking energy intensity despite an increase in average activity from 1990 to 2007. Improved fleet practices, caused by an increase in the competitiveness of the transportation sector and by the introduction of electronic engines, have improved fuel efficiency in medium- and heavy-duty trucks.

FIGURE 1-21

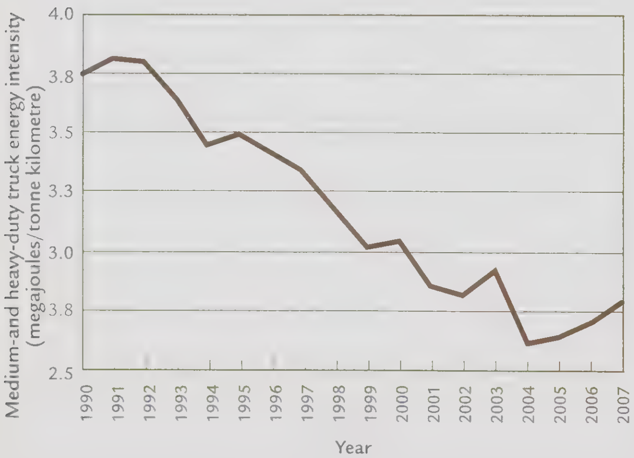
Average Activity per Truck, 1990 to 2007



Source: oee.nrcan.gc.ca/corporate/statistics/neud/dpa/handbook_tables.cfm?attr=0

FIGURE 1-22

Trucking Energy Intensity, 1990 to 2007



Source: Natural Resources Canada, Transportation End-Use Model, Ottawa, 2009

NRCan carries out the following initiatives to increase the efficiency of motor vehicle use:

- ecoENERGY for Personal Vehicles
- ecoENERGY for Fleets
- Clean Transportation Energy

TRENDS IN ALTERNATIVE AND RENEWABLE FUELS

Alternative and Renewable Fuels

Alternative fuels are fuels used for transportation other than petroleum-based gasoline and diesel. Some alternative transportation fuels, such as ethanol and biodiesel, are renewable; others, such as propane and natural gas, are non-renewable. Other possible alternative transportation fuels include next-generation biofuels, coal-to-liquids, electricity and hydrogen.

Renewable fuel is a broad term covering a range of fuels made from renewable energy sources that are naturally replenished in a relatively short period. The sources include biomass, hydropower, geothermal energy, wind energy and solar energy.

Biofuel is a well-known category of renewable fuel and can be produced from a variety of sources. Two commercially available biofuels are ethanol and biodiesel. Conventional ethanol is produced from sugars or starches, and biodiesel production typically uses vegetable oils and animal fats. In Canada, ethanol is typically produced from corn and wheat, while canola oil, soy oil and tallow are relevant biodiesel feedstocks.

Gasoline vehicles manufactured since the 1980s can use up to 10 percent ethanol in gasoline. An increasing number of original equipment manufacturers are endorsing the use of lower biodiesel blends, for example, up to 5 percent in diesel engines. Under development are next-generation biofuels, such as cellulosic ethanol. These biofuels could be made from non-conventional

sources, such as agricultural residues, forest residues and waste materials.

Renewable Fuels Production

Renewable fuels production in Canada has increased since the emergence of ethanol in Manitoba in the 1980s. Between 2005 and 2009, domestic renewable fuel production capacity increased approximately eightfold, from 211 million litres (L) to 1.65 billion L per year. By the end of 2009, ethanol production capacity was 1.5 billion L and biodiesel production capacity was more than 150 million L. For the 2009 calendar year, 1.1 billion L of ethanol and approximately 102 million L of biodiesel were actually produced.

In 2008, renewable fuels used in the transportation sector represented an estimated 2 percent of fuel used. The renewable fuel consumed was predominately ethanol blended with gasoline in lower-level ethanol blends.

Environment Canada announced that the Renewable Fuels Regulations requiring gasoline producers and importers to have an annual average renewable fuel content of at least five percent based on the volume of gasoline produced and imported came into force on December 15, 2010. The federal government also intends to regulate a 2 percent requirement for renewable content in diesel fuel and heating oil by 2011, subject to technical feasibility.

NRCan carries out initiatives to increase the use and production of renewable and alternative fuels under the following programs:

- ecoENERGY for Biofuels
- National Renewable Diesel Demonstration Initiative
- Sustainable Development Technology Canada's NextGen Biofuels Fund™

CHAPTER 2

Equipment, Standards and Labelling

INTRODUCTION

Natural Resources Canada's (NRCan's) wide range of energy efficiency initiatives includes standards and labelling programs that are based on the requirements of Canada's *Energy Efficiency Regulations* (the Regulations).

The *Energy Efficiency Act* (the Act) of 1992 gives the Government of Canada the authority to make and enforce regulations that prescribe standards and labelling requirements for energy-using products that are imported to Canada or shipped across provincial borders for lease or sale. The Act was amended in 2009, making it possible to prescribe standards not only for more products that use energy but also for products, such as thermostats, that affect energy use. The Regulations came into effect in February 1995, after extensive consultations with provincial governments, affected industries, utilities, environmental groups and others. Since then, the Regulations have been amended a number of times.

Regulations have now been established for more than 40 products, including major household appliances, water heaters, heating and air-conditioning equipment, automatic icemakers, dehumidifiers, dry-type transformers, electric motors, commercial refrigeration and some lighting products. The Regulations apply to these products even if they are incorporated in a larger unit or machine that is not regulated.

The performance standards contained in the Regulations and accompanying labelling requirements and programs make a major contribution to the Government of Canada's Clean Air Regulatory Agenda. In October 2006, a notice of intent was published for amending the Regulations to prescribe standards for 20 new products and increase the stringency of existing standards for 10 products by 2010. When all the standards are implemented, there will be a standard in place for products that use 80 percent of the energy consumed in the residential and commercial/institutional sectors.

NRCan regularly amends the Regulations to strengthen the minimum energy performance requirements for prescribed products when the market has achieved a higher level of efficiency. The Regulations are also amended to add new products, harmonize minimum energy performance requirements with those of other jurisdictions and update testing methodologies and labelling requirements.

In addition, regulations can be established for gathering market data on the energy performance of certain types of equipment. For example, the data gathered for gas fireplaces are used to support programs developed by the industry and NRCan and its partners for gas fireplace performance.

Before amending the Regulations, NRCan conducts studies to determine how the proposed change will affect the market. A key criterion for amending the Regulations is that the change must have a significant positive impact on consumers and the environment. Stakeholders are consulted on all proposed changes to the Act and the Regulations, as well as on their practical application in the marketplace.

The Act and the Regulations also support labelling initiatives. These initiatives are designed to help consumers and the commercial/industrial procurement community identify and purchase energy-efficient equipment that will save them money and reduce greenhouse gas (GHG) emissions over the life of the product.

The Act and the Regulations require that a comparative EnerGuide label be displayed on major electrical household appliances and room air conditioners or, as in the case of the newly implemented requirement for light bulb labelling, on the product packaging. The EnerGuide label shows the energy performance of the product and compares it with the most and least efficient models of the same class and size.

The EnerGuide label is also used voluntarily by manufacturers and suppliers of residential oil and gas furnaces, vented gas fireplaces, central air conditioners and air-to-air heat pumps. In this case, the EnerGuide rating for a specific product is published on the back page of the manufacturer's brochure. These ratings include the annual fuel utilization efficiency rating for oil and gas furnaces, the fireplace efficiency rating for gas fireplaces and the seasonal energy efficiency ratio for central air conditioners.

The ENERGY STAR® Initiative in Canada works with and complements the Regulations and comparative EnerGuide label. The internationally recognized ENERGY STAR symbol is a simple way for consumers to identify products that are among the most energy-efficient on the market.

Products that are prescribed in the Regulations and are also part of ENERGY STAR must meet levels of energy efficiency significantly above the minimum performance levels set out in the Regulations to qualify for the ENERGY STAR symbol. As higher-performance products penetrate the market, their efficiency levels trigger the development of new minimum energy performance standards.

STANDARDS

As a world leader in the use of energy efficiency standards, NRCan is committed to harmonizing standards and labelling requirements with those developed in other jurisdictions. Harmonization reduces barriers to trade and sustainable development by improving the flow of energy-efficient products within Canada and around the world. This practice minimizes the regulatory burden on manufacturers and avoids confusion for consumers.

For example, the performance requirements in the Regulations are similar to those in the five Canadian provinces that currently regulate energy-using equipment manufactured and sold within their borders. This alignment is achieved because governments support and participate in the development of national, consensus-based performance standards by accredited standards-writing organizations, such as the Canadian Standards Association.

Such standards include testing procedures that are used to determine a product's energy performance and are usually referenced federally and provincially. NRCan works closely with provinces throughout the regulatory process to ensure that the federal and provincial standards regimes are harmonized to the maximum extent possible.

Because the North American market is highly integrated, Canada's energy performance requirements for many products are strongly aligned with regulations in the United States.

Canada is an active participant in international and regional forums, such as the Security and Prosperity Partnership of North America, involving the United States and Mexico, and the Asia-Pacific Partnership on Clean Development and Climate. Both of these efforts contribute to regional co-operation on harmonization issues. Trade and investment liberalization and facilitation are high on the agenda of these working groups.

NRCan is also involved with the International Energy Agency's Efficient Electrical End-use Equipment (4E) initiative that facilitates co-operation among various Organisation for Economic Co-Operation and Development (OECD) countries on specific projects. Canada is participating in a mapping and benchmarking study as well as one on standby power.

COMPLIANCE AND ENFORCEMENT

The Regulations outline a number of responsibilities for dealers who import to Canada, or ship from one Canadian province to another, any prescribed energy-using product. NRCan is committed to securing voluntary compliance but can use enforcement measures when necessary.

NRCan emphasizes self-monitoring, reporting, voluntary compliance and collaboration. However, the Act prescribes specific enforcement measures when dealers violate the law.

Enforcement activities include preventing the importation of non-compliant products to Canada, preventing the sale or lease of non-compliant products in Canada and imposing fines. Violators can also be fined under the Administrative Monetary Penalty System of the Canada Border Services Agency for not providing required information on the prescribed product at the time of import; serious violations can be prosecuted.

To monitor compliance with the Regulations, NRCan captures information from energy efficiency reports and import documents. Section 5 of the Act requires dealers to provide energy efficiency reports when they market a new product model. The required information includes the energy performance of each model, the name of the testing agency and the size category, as described in Schedule IV of the Regulations.

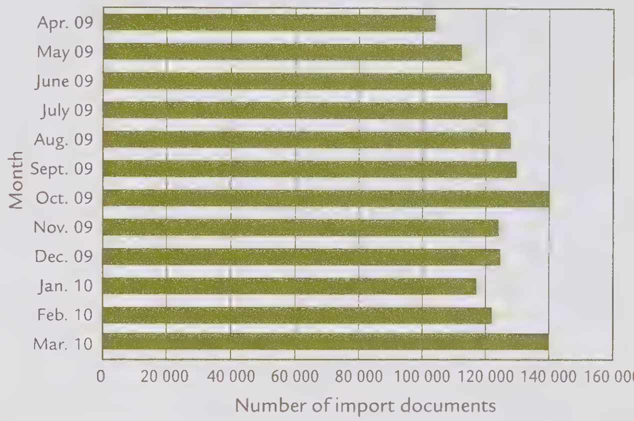
The Regulations require that when importing a regulated product into Canada, dealers provide specific product information on customs documents for all shipments (i.e. type of product, brand name, model number, address of dealer and purpose of import). A customs document contains less information than an energy efficiency report, but there is enough to allow NRCan to verify that there is a matching energy efficiency report. NRCan can then confirm that all products entering Canada meet the required energy performance levels and can take action when necessary.

NRCan processed more than 1 493 214 records (records from April 1, 2009, to March 31, 2010) relating to the importation of regulated energy-using products to Canada in 2009–2010.

Figure 2-1 illustrates the volume of import documents received, in paper form and electronically, per month during the 2009–2010 fiscal year.

FIGURE 2-1

Volume of Monthly Import Documents



Source: OEE Equipment Database.

More than 1 824 516 new or revised model numbers were submitted to NRCan for entry into NRCan's equipment database (records from April 1, 2009, to March 31, 2010) from dealers' energy efficiency reports.

REGULATORY IMPACT TO DATE FROM THE REGULATORY IMPACT ANALYSIS STATEMENT

In preparing amendments to the Regulations, NRCan analyses the impact of the proposed amendment on society, the economy and the environment. This information is made available through the Regulatory Impact Analysis Statement, which is annexed to the Regulations and published in the *Canada Gazette, Part II*.

It is estimated that Canada's energy performance standards from the 10 amendments would cause a reduction of 26 megatonnes (Mt) in aggregate annual emissions by 2010 (see Table 2-1).

TABLE 2-1

Estimated Impact of *Energy Efficiency Regulations*, 2010 and 2020 (Aggregate Annual Savings)

Product (amendment number in brackets)	Energy savings (PJ)		CO_2 reductions (Mt)	
	2010	2020	2010	2020
Residential appliances (1)	117.20	133.84	13.26	15.60
Lamps – fluorescent/incandescent (2)	11.60	13.40	7.55	9.80
Motors (3)	16.30	17.70	2.03	2.14
Commercial HVAC (4)	6.40	7.50	0.43	0.57
Refrigerators (5)	4.92	10.96	0.49*	1.10*
Ballast/room A/C, PAR lamps (6)	3.96	9.44	0.39*	0.94*
Clothes washers, domestic hot water, exit signs, chillers (8)	16.20	42.67	1.29	3.61
A/C, commercial refrigeration (9)	1.57	5.35	0.16	0.53
General service lighting, commercial and industrial gas unit heaters, traffic and pedestrian signals, ceiling fan lighting, torchiere lamps, commercial clothes washers, residential wine chillers, commercial ice-makers, residential dishwashers, residential dehumifiers, residential gas furnaces (10)	6.09	88.10	0.40	9.67
Total	**184.24**	**328.96**	**26.00**	**43.96**

* Values are different from Regulatory Impact Analysis Statement due to a change in the emission factor to 99.3.

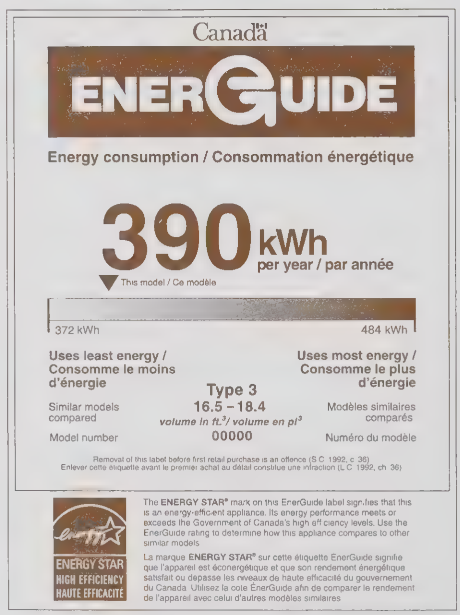
LABELLING AND PROMOTION

Since 1978, the EnerGuide label (see Figure 2-2) has given Canadians an opportunity to compare the energy consumption of appliances. In 1995, with the introduction of the Regulations, placing an EnerGuide label on major electrical household appliances and room air conditioners became mandatory. The label on a product shows how much energy a product uses, allowing the customer to consider the most energy-efficient choice.

EnerGuide directories that list energy ratings for major appliances and room air conditioners are published annually. They are distributed to consumers, retailers and appliance salespeople. In fulfilling requests for information, electric utilities and provincial governments also distribute the directories. Online directories for all appliances and heating and cooling equipment are published on the Web site of the Office of Energy Efficiency (OEE) and updated monthly.

FIGURE 2-2

EnerGuide Label



A voluntary EnerGuide rating program was established in 1997 and included gas furnaces, central air conditioners, heat pumps and oil furnaces. In the fall of 2003, gas fireplaces were added to the EnerGuide rating program, and manufacturers were asked to include EnerGuide ratings for fireplace efficiency in their brochures. These changes coincided with the mandatory requirement in the Regulations to test, verify and report on fireplace efficiency.

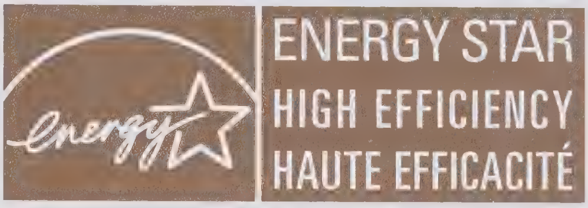
Major distributors of these products for sale in Canada report the verified energy performance rating of their products, as tested against the standards in the Regulations. In addition, participants in the voluntary EnerGuide rating program must provide shipment data and aggregate energy efficiency information to track the progress of the program and identify marketplace improvements that can result from labelling.

Given that the equipment products listed above are typically purchased from a brochure or catalogue, a consumer would probably not read the EnerGuide label before making a decision to buy. Accordingly, manufacturers are encouraged to include an EnerGuide rating in product brochures and catalogues, so consumers can compare the efficiency of products when they are in the buying process. To date, manufacturers of 85 percent of eligible products on the market voluntarily participate in the EnerGuide rating program and publish the ratings in their brochures.

Regularly conducted polls indicate that more than 50 percent of Canadians surveyed are aware of the EnerGuide label.

In 2001, responding to public interest in a labelling system that identifies the best performers, Canada officially introduced ENERGY STAR, the international symbol for energy efficiency (see Figure 2-3). Canada signed an agreement with the U.S. Environmental Protection Agency and the U.S. Department of Energy. The OEE is the custodian of the program for Canada. Canada joins other international ENERGY STAR program participants: Australia; New Zealand; Japan; Taiwan; and the European Union, which adopted ENERGY STAR for office equipment.

FIGURE 2-3
ENERGY STAR® Symbol



ENERGY STAR establishes high efficiency criteria and levels for selected products for the residential and commercial sectors. Product categories are selected on the basis of their technical potential for high efficiency. This is a voluntary program. However, organizations must demonstrate that products meet the eligibility criteria and performance levels. For appliances and heating and cooling products, the criteria are based on the same test standards as those applied under the Regulations. Canada promotes specific product categories for which levels and criteria can be harmonized with those of the United States, including the following:

- major electrical appliances
- heating, cooling and ventilation
- consumer electronics
- office equipment
- windows, doors and skylights (Canadian levels)
- selected lighting products – compact fluorescent lamps (CFLs), fixtures, decorative light systems and solid-state lighting
- selected commercial equipment, including commercial refrigeration products

Canada has also integrated ENERGY STAR with the EnerGuide label for qualified major appliances and room air conditioners, to help consumers identify

the best-performing products. While the EnerGuide label shows how much energy a product uses under normal conditions in one year, the ENERGY STAR symbol on the label identifies the most energy-efficient product. Now that industry-accepted standards of high efficiency have been established, ENERGY STAR has become the criterion to meet for incentive and rebate programs.

ENERGY STAR is used as the basis for incentives by many electrical and gas utilities across Canada. For example, Hydro-Québec promotes ENERGY STAR qualified refrigerators, freezers, clothes washers and CFLs as part of its *Mieux Consommer* program and provides incentives for these product categories. Enbridge Gas developed an incentive program around ENERGY STAR qualified tankless water heaters, and Manitoba Hydro ran an aggressive incentive program for ENERGY STAR qualified commercial kitchen equipment.

ENERGY STAR is also the qualifying criterion for sales tax exemptions in British Columbia for heating and cooling equipment, in Saskatchewan for the purchase of furnaces and boilers, and in Ontario for ENERGY STAR qualified geothermal heating equipment. Organizations across Canada have used ENERGY STAR as a campaign driver to promote replacement with, or purchase of, higher efficiency products.

Continuous promotion of ENERGY STAR qualified appliances has paid off. Industry statistics for 2008 show an increase in market penetration from almost nil in 1999 to 53 percent for refrigerators, 64 percent for clothes washers and 89 percent for dishwashers (see Figure 2-4). The increase in market penetration indicates growing acceptance of ENERGY STAR as the brand for high energy efficiency and manufacturers' willingness to raise the efficiency of their products to qualifying levels.

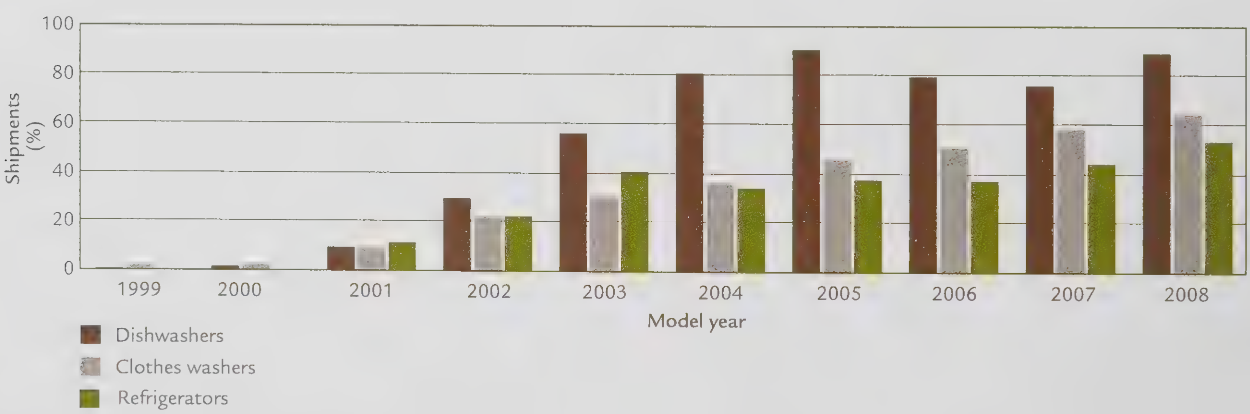
ENERGY STAR specifications and levels are periodically updated as product saturation is reached, to encourage industry to strive for more efficient products and thus maintain the relevance and credibility of the brand.

ENERGY STAR is also well known in the commercial sector, with criteria for products ranging from office equipment to vending machines. NRCan supports demonstration projects to validate the savings and other benefits of some of these products and to address barriers to their widespread acceptance.

Canada continues to promote ENERGY STAR guidelines in its contacts with the procurement community. It has updated an interactive cost calculator that compares energy cost savings and GHG emissions reductions associated with the purchase of ENERGY STAR qualified products.

FIGURE 2-4

Distribution of ENERGY STAR qualified shipments of appliances, 1999 to 2008



Source: *Energy Consumption of Major Appliances Shipped in Canada. Trends for 1990–2008.*

Workshops were held across Canada to make governments and institutions aware of the ENERGY STAR criteria and procurement tools.

Canada is also working with housing agencies to help them identify energy savings in their properties and to specify ENERGY STAR qualified products for replacement equipment.

Canada continues to expand the range of product types included in its ENERGY STAR agreement. Canada led the way in the development of a technical specification for decorative light strings (also known as Christmas lights) and implemented this specification for Canada. In addition, Canada recently included fixtures, solid state lighting and external power supplies in its agreement with the Government of the United States. Finally, Canada developed an ENERGY STAR specification for heat recovery ventilators.

NRCan developed a rating and labelling system for efficient refrigeration applications in ice and curling rinks under the name CoolSolution.[6] An ice rink application is qualified CoolSolution if it achieves a rating higher than 50 percent. An incentive program to encourage the adoption of CoolSolution and reduce the initial payback of the first applications started in November 2006. Partnerships to accelerate the program have been successful.

CoolSolution designates innovative technologies and practices and consists of three main elements:

- heat recovery from the refrigeration system to meet all the building's heating requirements (e.g. hot air, hot water) or to export this energy for other purposes
- adaptation to the Canadian climate by taking advantage of the naturally occurring cold temperatures. This is done by varying the temperature of the heat released into the environment according to the outdoor temperature.
- reduction of the synthetic refrigerant charges of the refrigeration system, which have a serious adverse impact on climate change. This is done by using natural refrigerants or by confining the synthetic refrigerant to the mechanical room and using environmentally friendly fluids to remove and distribute heat.

[6] CoolSolution is an official mark of Her Majesty the Queen in the Right of Canada as represented by the Minister of Natural Resources.

ecoENERGY FOR EQUIPMENT

Objective

To exclude the least efficient energy-using equipment from the market and to influence consumers to select – and manufacturers to produce – energy-efficient products that perform above minimum standards.

Description

The ecoENERGY for Equipment program is focused on accelerating the introduction of energy-efficient products in Canada's equipment stock. The program implements minimum energy efficiency performance standards that restrict the importation and interprovincial shipment of the least efficient products for sale in Canada. It also carries out initiatives to increase the market share of more efficient products.

ecoENERGY for Equipment also supports labelling programs that encourage the introduction of more efficient technologies. This involves the establishment and promotion of high-efficiency performance criteria, such as ENERGY STAR, and the engagement of stakeholders to promote products that meet these criteria. As products are adopted in the marketplace, the ENERGY STAR or equivalent performance level will become the basis for new, more stringent standards.

In addition, ecoENERGY for Equipment maintains a multilayered compliance and enforcement program to ensure that products meet prescribed

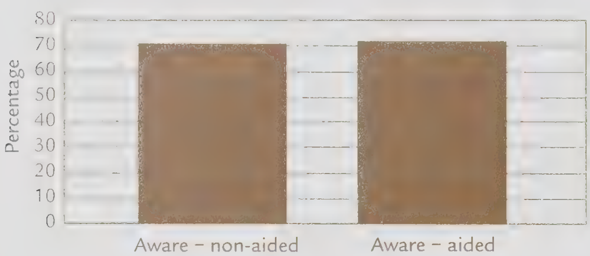
standards and to ensure that other regulatory requirements, such as labelling, are met.

Program components include the following:

- regulations under the *Energy Efficiency Act* (the Act) requiring dealers to ship only products that meet the prescribed energy efficiency standards
- the EnerGuide program, which rates and labels the energy efficiency of major household electrical appliances and heating, ventilating and air-conditioning equipment, assisting consumers in making energy-wise purchases
- the ENERGY STAR high efficiency program, which is an international initiative that identifies the most energy-efficient products in their class

FIGURE 2-5

ENERGY STAR Awareness Levels in Canada, 2010



Source: Tracking Study: Awareness of ENERGY STAR/EnerGuide Symbols 2010, Ipsos Reid.

Key 2009–2010 Achievements

- Amended the *Energy Efficiency Act* in September 2009, allowing for energy efficiency standards to be set for products that affect energy consumption, including windows and doors, as well as thermostats and other energy-system control devices. The amendment also clarified the authority to prescribe standards for classes of products that may be based on common energy-using characteristics. For example, a standard for all products that consume electricity in standby mode (when the product is turned off) could be prescribed by using the powers clarified in the amended Act.
- Since 2008, seven new product standards and four more stringent standards have been implemented.
- In fiscal year 2009–2010, ENERGY STAR criteria were developed for five new products, and eight existing criteria were revised. Two hundred and sixty-five companies joined the ENERGY STAR Initiative in Canada for a total of 1135 participants.
- Conducted the analysis and consultation necessary to pre-publish Amendment 11 to the *Energy Efficiency Regulations*. Amendment 11 includes standards for six previously unregulated products and increases in the stringency of the existing standards for eight products.
- Delivered five specialized workshops on the use of the ENERGY STAR calculator to the procurement and institutional community.

For more information:

oee.nrcan.gc.ca/residential/energystar-energuide-r2000.cfm?attr=0

regulations.nrcan.gc.ca

CHAPTER 3

Energy Efficiency and Alternative Transportation Fuels

Natural Resources Canada's (NRCan's) Office of Energy Efficiency (OEE) aims to strengthen and expand Canada's commitment to energy efficiency in all sectors and increase the production and use of alternative transportation fuels in Canada. The OEE manages the ecoENERGY Efficiency Initiative, under the ecoENERGY suite of programs initiated on April 1, 2007. The ecoENERGY Efficiency Initiative includes the following programs:

- ecoENERGY Retrofit
- ecoENERGY for Buildings and Houses
- ecoENERGY for Industry
- ecoENERGY for Personal Vehicles
- ecoENERGY for Fleets
- ecoENERGY for Biofuels
- ecoENERGY for Equipment (see Chapter 2)

In addition to ecoENERGY, the OEE manages the Federal Buildings Initiative and the National Renewable Diesel Demonstration Initiative.

This chapter describes the objective of each of the aforementioned programs and outlines key achievements.

ecoENERGY RETROFIT

Objective

To provide incentives for energy efficiency improvements in homes and in small and medium-sized organizations in the institutional, commercial and industrial sectors. The program has two components:

- ecoENERGY Retrofit – Homes
- ecoENERGY Retrofit – Small and Medium Organizations

For more information:

oee.nrcan.gc.ca/retrofit

ecoENERGY RETROFIT – HOMES

Objective

To assist homeowners and owners of existing low-rise properties make smart energy retrofit decisions that will result in significant energy savings and a cleaner environment.

Description

Initiated on April 1, 2007, the ecoENERGY Retrofit – Homes program is investing $745 million over four years, providing federal grants to property owners for improving the energy efficiency of their homes and reducing their home's impact on the environment. ecoENERGY Retrofit – Homes offers a professional evaluation by a qualified energy advisor of the energy efficiency characteristics of a house, including a diagnostic test to determine air leakage.

The energy advisor prepares a detailed personalized checklist of recommended upgrades for the property owner, including the EnerGuide pre-retrofit energy rating of the house. The checklist shows the recommended, most effective upgrades. The property owner chooses which upgrades to have done.

After the retrofit work is complete, the advisor performs a post-retrofit energy evaluation and

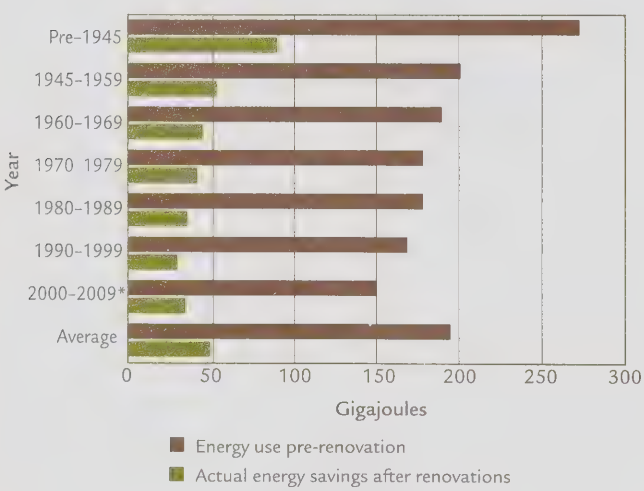
assigns a new energy-rating label. After the required improvements have been made, the property owner is entitled to a grant.

In fiscal year 2009–2010, an additional $285 million was allocated to the ecoENERGY Retrofit – Homes program in response to unprecedented demand, bringing the total budget for this element to $745 million over four years. On March 31, 2010, the program ceased accepting bookings for pre-retrofit evaluations, but continued to process grant applications from homeowners who had these evaluations and remained eligible. This demonstrated prudent program management and ensured that all eligible homeowners who previously entered the program had the opportunity to apply for a grant.

Figure 3-1 illustrates the energy use and savings gained per household before and after renovations.

FIGURE 3-1

Residential Energy Use and Energy Savings per Household, Pre-1945 to 2000–2009



*Data for 2007 are from ecoENERGY Retrofit – Homes (previous data source was EnerGuide for Houses).

Key 2009–2010 Achievements

- As of March 31, 2010, the ecoENERGY Retrofit – Homes program received more than 290 000 grant applications and performed nearly 610 000 pre-retrofit evaluations. The program has provided more than $350 million to more than 275 000 grant recipients. Participants reduced their annual energy consumption by about 22 percent and greenhouse gas (GHG) emissions by approximately 3 tonnes per house per year.
- Over the same time period, more than 73 000 grants were paid for more energy-efficient renewable technologies and products, including water conservation equipment, wood burning appliances, ground-source heat pumps, solar domestic hot water systems and drain water treatment recovery pipes (representing 25 percent of program participants).
- All regions of Canada, except one territory, have full or partial matching programs from which homeowners can get seamless access to both federal and provincial/territorial government support for home retrofits.
- Since program inception, a reduction of approximately 0.90 megatonnes (Mt) of GHG emissions can be attributed to the ecoENERGY Retrofit – Homes program.

ecoENERGY RETROFIT – SMALL AND MEDIUM ORGANIZATIONS

Objective

To encourage building owners and managers of commercial and institutional buildings and industries to implement energy efficiency projects.

Description

Initiated on April 1, 2007, ecoENERGY Retrofit – Small and Medium Organizations is investing $40 million over four years, providing financial incentives to implement energy retrofit projects in buildings and industrial equipment and processes. Industrial facilities with fewer than 500 employees and commercial and institutional buildings of less than 20 000 square metres may be eligible for funds through contribution agreements with the program.

ecoENERGY Retrofit – Small and Medium Organizations was originally a five-year program. However, demand was less than expected, and on April 30, 2010, the Government of Canada announced that the program would end in March 2011. Until then, projects continue to be approved, and no existing agreements are affected. Applications continue to be processed on a first-come, first-served basis until March 31, 2011, or until all funds are allocated.

ecoENERGY Retrofit provides up to 25 percent of the cost of a project, to a maximum of $50,000, based on estimated energy savings resulting from the project. Recipients of funding in this category may also qualify for funding support from utilities and/or other levels of government. To qualify, eligible organizations must submit an application detailing the energy efficiency project, including the total budget, timeframe for completion and expected results, based on a certified technical assessment of the building's or industry's energy use.

Key 2009–2010 Achievements

- As of March 31, 2010, 848 contribution agreements had been signed in the buildings and industry sectors (494 buildings projects and 354 industry projects). These agreements are for projects worth $161 million, yielding annual energy cost savings of $29 million.
- More than 1900 buildings and industry sector participants took part in webinars and information sessions.
- Since program inception, the program has approved projects that will save approximately 0.156 Mt of GHG emissions.

ecoENERGY FOR BUILDINGS AND HOUSES

Objective

To encourage the construction and operation of more energy-efficient buildings and houses through a range of complementary activities, such as rating, labelling and training.

Description

Initiated on April 1, 2007, the ecoENERGY for Buildings and Houses program is investing $60 million over four years and includes the following activities for the buildings sector:

- implementing new design tools and training, including building design simulation for new buildings and the Dollars to $ense Energy Management workshops for existing buildings, so designers, builders, owners and operators can learn about and use best practices and new technologies to improve the energy efficiency of new and existing buildings
- updating building energy ratings and promoting labelling systems for housing, including the EnerGuide Rating System (ERS), the R-2000 Standard[7] and ENERGY STAR® for New Homes, to encourage consumers to invest in energy-efficient upgrades during the construction planning phase of building a new home (see Figure 3-2)

FIGURE 3-2

Number of R-2000 Housing Certifications, 1990 to 2009

Source: NRCan national housing database and internal data.

7 R-2000 is an official mark of Natural Resources Canada.

- supporting the National Research Council financially in upgrading the *National Energy Code for Buildings*, last published in 1997
- engaging in ongoing dialogue and co-operation with provincial and territorial programs to encourage other levels of government to adopt more stringent building energy codes
- providing training and implementing outreach and communication strategies to increase awareness and build capacity among builders, building owners, managers and consumers to support the adoption of sustainable energy efficiency programs
- establishing and maintaining partnerships to reduce energy use and improve energy efficiency information

Key 2009–2010 Achievements

- By March 31, 2010, more than 4000 building owners, managers, operators, designers and builders had received energy management training, while almost 400 commercial buildings received energy labels as part of a pilot energy management labelling and benchmarking program.
- Issued more than 540 000 housing labels for new and existing houses.
- More than 1700 building professionals took part in technical support workshops, and more than 4700 housing professionals, builders and energy advisors were trained.
- As of the end of the 2009–2010 fiscal year, six provinces (B.C., Man., Ont., Que., N.B., N.S.) had announced changes to their building codes to achieve the ERS80 level by 2012. Eleven provinces and territories participate in the Building Energy Codes Collaborative.
- More than 75 percent of new homes are constructed in provinces that have announced the intent to increase the minimum ERS level of new homes to ERS80 by 2012. This represents a 30 percent decrease in energy consumption when comparing with homes built according to the requirements of the 2006 building code.
- Since program inception, an estimated 1.07 Mt of GHG emissions were saved as a result of the ecoENERGY for Buildings and Houses program.

For more information:

ecoaction.gc.ca/ecoenergy-ecoenergie/buildingshouses-batimentshabitations-eng.cfm

ecoENERGY FOR INDUSTRY

Objective

To improve industrial energy intensity and reduce energy-related industrial GHGs and air pollution.

Description

Initiated on April 1, 2007, the ecoENERGY for Industry program is investing $18 million over four years to accelerate energy-saving investments and exchange best-practices information within Canada's industrial sector. The program helps industry become more energy efficient by providing tools, training and cost-shared studies to enable industry to identify opportunities, calculate payback and overcome technical, management and financial barriers to energy efficiency project implementation.

The Canadian Industry Program for Energy Conservation (CIPEC) is an industry-government partnership delivered through the ecoENERGY for Industry program. The CIPEC network encompasses more than 50 associations and 25 industrial sectors, covering 98 percent of industrial energy use in Canada. Registered CIPEC Leader companies voluntarily commit to energy efficiency improvements as well as to reducing GHG emissions. Innovative companies at the leading edge receive recognition though the national CIPEC Leadership Awards.

Key program elements include the following:

- the Dollars to $ense Energy Management workshops, which teach industry members how to improve operational efficiency, create a better work environment and reduce GHG emissions
- the ecoENERGY Assessment Incentive for Industry, which offers a cost-shared solution to help industrial companies conduct state-of-the-art process integration and computational fluid dynamics studies that identify opportunities to increase energy efficiency and improve production processes. Typically, opportunities for annual energy savings of 10 percent to 25 percent are identified.
- the CIPEC Leaders network, which demonstrates industry sector commitment to reducing energy use, provides members with opportunities for networking, recognition and sharing of best-practices, as well as eligibility for financial incentives
- tools, publications and benchmarking studies that create awareness of energy-saving opportunities and promote actions to achieve those savings

Key 2009–2010 Achievements

- More than 3100 industrial energy managers have attended the Dollars to $ense Energy Management workshops since program inception, with 1060 trained in 2009–2010. Customized workshops are held on-site to facilitate access in remote locations.
- Welcomed 320 new members to the CIPEC Leaders network, which now has 2100 members, and held 35 network meetings.
- Organized and hosted the Energy 2009 Industrial Energy Efficiency Conference and awards gala, which attracted 400 participants from industry, utilities and academia.
- Since program inception, the ecoENERGY for Industry program helped Canadian industry avoid approximately 1.11 Mt of GHG emissions.

For more information:

ecoaction.gc.ca/ecoenergy-ecoenergie/industry-industrie-eng.cfm

ecoENERGY FOR PERSONAL VEHICLES

Objective

To facilitate and support improvements in energy efficiency by encouraging Canadians to buy, drive and maintain their vehicles with fuel efficiency in mind.

Description

Initiated April 1, 2007, the ecoENERGY for Personal Vehicles program is investing $21 million over four years to provide Canadians with information, tips and decision-making tools to assist them in changing their buying, driving and maintenance behaviours in order to reduce fuel consumption and GHG emissions from their personal vehicle use. It does so through the following:

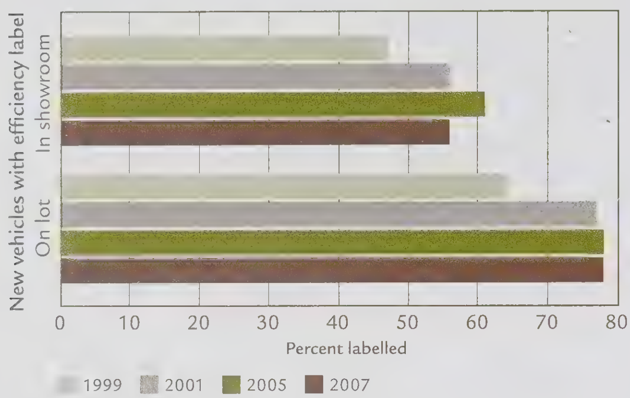
- decision-making information and tools, such as the annual *Fuel Consumption Guide*, labels and vehicle awards
- "Eco" driver education and training
- idle-free and tire inflation campaigns
- collaborative ventures with community groups and industry stakeholders

ecoENERGY for Personal Vehicles also facilitates work with the vehicle industry to implement and monitor the voluntary memorandum of understanding (MOU) between the Government of Canada and the auto industry to reduce automobile GHG emissions.

Program components include the following:

- the EnerGuide labelling system, which places fuel consumption labels on all new light-duty vehicles sold in Canada (see Figure 3-3)

FIGURE 3-3
New Vehicle Fuel Efficiency Labelling



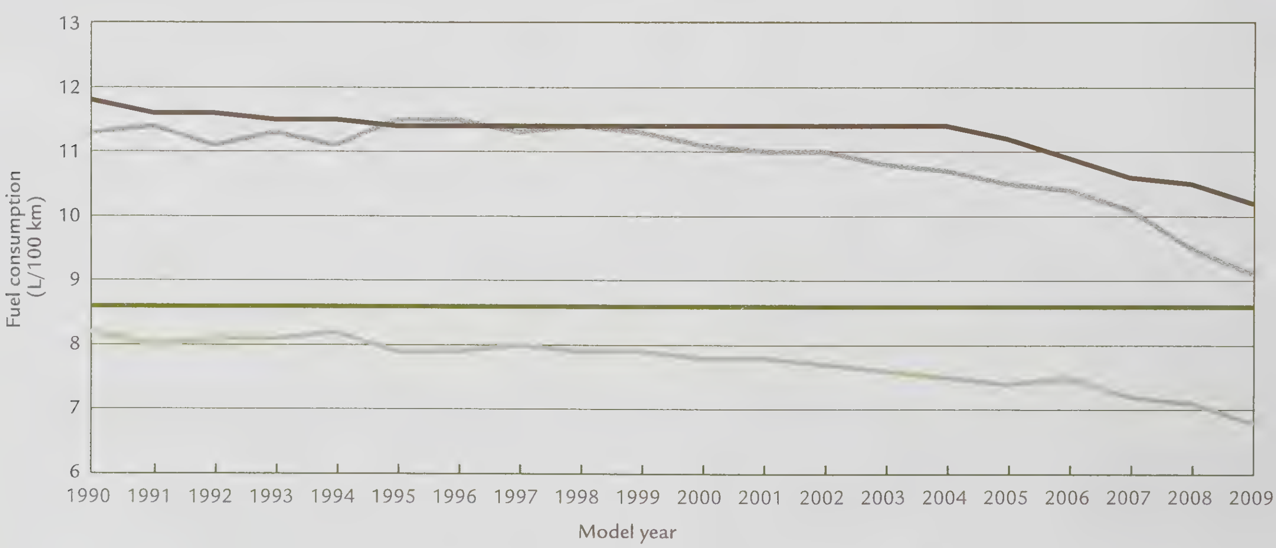
Source: Corporate Research Associates, *2007 EnerGuide Label for Vehicles and Fuel Consumption Guide Audit Survey: Final Overall Report*, May 2007.

- the 2005 MOU between the Government of Canada and the Canadian auto industry – a framework for automakers to produce more fuel-efficient and lower-GHG-emission vehicles by 2010 (see Figure 3-4)
- the annual ecoENERGY for Vehicles Awards, which recognize and identify, for consumers, the most fuel-efficient light-duty vehicles in their classes available in Canada
- the Auto$mart driver education series, which teaches drivers how to drive safely, save fuel and money, and protect the environment by using fuel-efficient driving techniques
- idle-free and tire maintenance campaigns that use educational materials and outreach activities to encourage drivers to embrace fuel-efficient practices

Key 2009–2010 Achievements

- In fiscal year 2009–2010, more than 350 000 new drivers were trained using materials from the Auto$mart fuel-efficient driving curriculum. A fuel savings of 5 percent to 25 percent is possible when drivers adopt fuel-efficient driving techniques.
- Distributed more than 300 000 copies of the *2009 Fuel Consumption Guide*, including 117 000 copies to 3400 new car dealerships and 600 to Canadian Automobile Association offices.

FIGURE 3-4
Company Average Fuel Consumption (CAFC) Versus Canadian Voluntary Standards, 1990 to 2009*



*2009 data are estimates.
Source: www.tc.gc.ca/eng/programs/environment-fcp-cafctargets-385.htm

- All provinces and most territories have incorporated fuel efficiency into driver education handbooks.
- Nearly 21 million Canadians have been reached through targeted campaigns on fuel-saving practices related to idling and tire inflation since the program was launched in 2007. In 2009–2010, the "Be Tire Smart" campaign reached 9 million people about the environmental and fuel economy benefits of proper tire inflation and regular maintenance.
- To date, the estimated GHG emission reductions associated with idle reduction and tire maintenance campaigns and with new driver training are 0.1 Mt.

For more information:

vehicles.nrcan.gc.ca

ecoENERGY FOR FLEETS

Objective

To achieve reductions in fuel use and related costs and GHG emissions through a wide range of measures targeting operators and managers of Canada's commercial and institutional road vehicle fleets.

Description

Initiated April 1, 2007, the ecoENERGY for Fleets program is investing $22 million over four years to promote the adoption of existing and emerging new technologies, such as energy-efficient vehicle components and hybrid technologies, and best practices, such as fuel management techniques.

ecoENERGY for Fleets is aimed at the commercial/institutional fleet transportation sector and provides information, workshops, technical demonstrations and training programs on fuel-efficient practices for fleet vehicles.

Program components include the following:

- Fuel Management 101 workshops, which assist fleet managers with the preparation, implementation and monitoring of a fuel management plan
- SmartDriver training programs, which offer knowledge sharing and on-the-road instruction to drivers of various types of fleets for the purpose of reducing fuel consumption
- funding for fuel-efficient technology demonstrations, which help overcome knowledge barriers, encouraging uptake of fuel-saving technologies by fleets

Key 2009–2010 Achievements

- In fiscal year 2009–2010, nearly 14 000 commercial drivers participated in SmartDriver training workshops and more than 360 participants took part in Fuel Management 101 workshops to promote greater uptake of transportation energy efficiency practices.
- Completed two idling awareness campaigns.
- Since program inception, a reduction of approximately 0.31 Mt of GHG emissions can be attributed to the ecoENERGY for Fleets program.

For more information:

fleetsmart.gc.ca

ecoENERGY FOR BIOFUELS

Objective

To support the production of renewable alternatives to gasoline and diesel and encourage the development of a competitive domestic renewable fuel industry.

Description

ecoENERGY for Biofuels provides an operating incentive to facilities that produce renewable

alternatives to gasoline, such as ethanol, and renewable alternatives to diesel, such as biodiesel, based on production volumes. The program will invest up to $1.48 billion over nine years, starting April 1, 2008, in support of biofuel production in Canada.

This program is expected to increase domestic production and develop a competitive domestic renewable fuel industry. The expected program volume is 2.5 billion litres (L) of domestic production by March 2012, with a target of 2 billion L of renewable alternatives to gasoline and 500 million L of renewable alternatives to diesel fuel.

In order to receive an incentive, eligible recipients must have signed a contribution agreement with NRCan and must have met the requirements of the *Canadian Environmental Assessment Act* and comply with all other applicable federal, provincial and municipal legislation.

Key changes to the program were announced in December 2009: a realignment of the nine-year funding allocation, a new payment regime and a new decision-making methodology.

ecoENERGY for Biofuels is a key component of Canada's renewable fuel strategy, which aims to

- reduce the GHG emissions resulting from fuel use
- encourage greater production of biofuels
- accelerate the commercialization of new biofuel technologies
- provide new market opportunities for agricultural producers and rural communities

Key 2009–2010 Achievements

- As of March 31, 2010, 21 contribution agreements had been signed with companies.
- These agreements represent a total commitment of $966.2 million and a domestic production of 1.6 billion L of biofuels (1.4 billion L of ethanol and 0.189 billion L of biodiesel).

For more information:
ecoaction.gc.ca/biofuels

FEDERAL BUILDINGS INITIATIVE

Objective

To assist Government of Canada organizations in implementing energy efficiency upgrades that lead to reduced energy and water use, GHG emissions and operating costs.

Description

The Federal Buildings Initiative (FBI) is an energy efficiency program targeting federal departments and agencies and Crown corporations. The FBI provides a range of products and services required by an organization to implement comprehensive energy efficiency improvement projects in its facilities.

FBI services include project facilitation, such as energy management technical advice, program policy advice and procurement services, to assist organizations in making energy efficiency improvements. The FBI uses a financing technique known as energy performance contracting, in which the cost of the job is paid for from the savings stream.

Other levels of government, institutions and private sector firms have drawn on the FBI's experience for help in designing their own energy efficiency programs using energy performance contracting. Since its inception in 1991, the FBI has helped upgrade thousands of square metres of federal building floor space, representing one third of the total federal floor space, saving $43 million in energy bills and reducing the risks associated with climate change.

Key 2009–2010 Achievements

- Since 2007–2008, the FBI has facilitated five new contracts with federal agencies: Canadian Forces Base Gander, Canadian Forces Base Gagetown, Foreign Affairs and International Trade Canada, Fisheries and Oceans Canada, and Public Works and Government Services Canada.

- In fiscal year 2009–2010, the FBI helped facilitate three potential projects. Two of them reached the request for proposal tendering and evaluation stage, and the third was close to procurement.

For more information:

oee.nrcan.gc.ca/fbi

NATIONAL RENEWABLE DIESEL DEMONSTRATION INITIATIVE

Objective

Initiated in December 2008, the National Renewable Diesel Demonstration Initiative (NRDDI) aims to address remaining questions from industry and end-users about renewable diesel use by demonstrating how it will perform under Canadian conditions.

Description

The Government of Canada is committed to expanding the production and use of a range of cleaner, renewable biofuels, including renewable diesel. The intent is to reduce GHG emissions that result from fuel use, encourage greater production of biofuels, accelerate the commercialization of new biofuel technologies and provide new market opportunities for agricultural producers and rural communities.

In December 2006, the government announced its intention to develop a regulation requiring an average annual 2 percent renewable fuel content in diesel fuel and heating oil by 2012, upon successful demonstration of renewable diesel fuel use under the range of Canadian conditions. More recently, the government has announced its intention to accomplish this by 2011, subject to technical feasibility.

Renewable diesel has been tested in a variety of vehicle engines under driving conditions in many parts of Europe and the United States. Renewable diesel has also been tested in certain applications in Canada, such as trucks, buses and marine vessels.

During consultation, Canadian industry sectors and end-users raised questions related to large-scale integration of renewable diesel into fuel distribution networks. The NRDDI aims to address these remaining questions in advance of the proposed regulation coming into effect.

Non-repayable contributions have been provided to approved projects that demonstrate aspects of renewable diesel use and/or distribution in Canada.

Key 2009–2010 Achievements

- Seventeen stakeholder organizations were consulted.
- Five contribution agreements and three MOUs were signed to deliver projects in forestry, construction, rail, electricity generation (gensets), home heating and agricultural applications to address stakeholder questions about cold weather operability, long-term storage, materials compatibility and sediment formation.
- Two projects were completed.
- A study that assessed infrastructure readiness for the proposed regulation was completed.

For more information:

oee.nrcan.gc.ca/transportation/fuels/biodiesel/NRDDI

CHAPTER 4

Clean Energy Science and Technology

INTRODUCTION

Natural Resources Canada (NRCan) invests in the research, development and demonstration (R,D&D) of new and emerging clean energy science and technology (S&T) that produces economic, social and environmental benefits for Canadians. NRCan's Office of Energy Research and Development (OERD) and CanmetENERGY lead the federal government's energy S&T operations.

The OERD oversees the management of the Program of Energy Research and Development (PERD), the ecoENERGY Technology Initiative and the Clean Energy Fund. These programs allocated more than $120.5 million in the 2009–2010 fiscal year. The funds help find new, long-term, cleaner and more efficient solutions to reducing environmental emissions by developing and disseminating new knowledge and new technologies through R,D&D initiatives. Slightly more than 75 percent of the programs and activities allocated by the OERD are managed and carried out by the Department (including CanmetENERGY). The six departmental priorities listed under CanmetENERGY also apply to the OERD.

CanmetENERGY generates and provides knowledge and technologies to advance the development and use of innovative solutions contributing to the well-being of Canadians and to progress toward meeting Canada's economic, social and environmental policy objectives. It works with industry, academia, utilities, associations, non-governmental organizations and other governments to develop and demonstrate energy-efficient, alternative and renewable energy technologies and processes.

CanmetENERGY undertakes projects and activities in the following areas of expertise:

- clean energy systems for buildings and communities
- clean electric power generation
- clean energy systems for industry
- clean transportation energy
- environmentally sustainable oil and gas development
- sustainable bioenergy

This chapter describes in detail the programs, activities and 2009–2010 key achievements of the OERD, CanmetENERGY and other partners in energy S&T.

For more information:

nrcan.gc.ca/eneene/science/resres-eng.php

canmetenergy.nrcan.gc.ca

PROGRAM OF ENERGY RESEARCH AND DEVELOPMENT

Objective

To fund research and development (R&D) designed to ensure a sustainable energy future for Canada in the best interests of its economy and the environment.

Description

PERD supports R&D activities within nine portfolios, comprising oil sands and offshore regulatory issues, sustainable bioenergy, the reduction of air impacts, the improvement of efficiency in electricity, the integration of alternative and renewable energy into the grid, and the improvement of efficiencies in end-use, with a focus on transportation, buildings and industry. Efficiencies are sought in energy production, distribution and end use. Examples of funded projects appear throughout this chapter.

The portfolios are managed holistically and encompass the entire innovation spectrum – from basic research to applied research, pilot plants and demonstrations, – ensuring faster deployment of technologies developed with federal funds.

The PERD budget for the 2009–2010 fiscal year was approximately $54.9 million. Of that amount, $17.4 million was allocated to 12 federal departments and agencies that are PERD partners, mostly to improve the science supporting Canadian regulations related to energy production and use. The remaining $37.5 million was allocated to energy R&D programs managed and performed in NRCan, more than 70 percent of which contributed to improved energy efficiency and the integration of renewable energy sources in Canada.

ecoENERGY TECHNOLOGY INITIATIVE

Objective

To support the development of next-generation energy technologies needed to break through to emissions-free fossil fuel production, as well as for producing energy from other clean sources, such as renewables and bioenergy, and to advance the development and use of new clean energy technologies in end-use sectors.

Description

The ecoENERGY Technology Initiative is a component of ecoACTION, the Government of Canada's actions toward clean air and greenhouse gas (GHG) emissions reductions. It is a $230-million investment in clean energy S & T. The funding helps in the search for long-term solutions to reducing and eliminating air pollutants from energy production and use.

Part of the funding has been allocated to the demonstration of carbon capture and storage. Eight projects have been selected in this area. Spending in the 2009–2010 fiscal year was nearly $45.6 million.

CLEAN ENERGY FUND

Objective

To fund the demonstration of technologies, including large-scale carbon capture and storage projects, and renewable energy and clean energy systems demonstrations to reduce GHG emissions reductions and increase the percentage of electricity produced from clean sources.

Description

The $795-million Clean Energy Fund, a component of Canada's Economic Action Plan announced in 2009, provides funding for the demonstration of promising technologies to support the Government of Canada's commitments to reducing GHG emissions. Approximately 20 percent of the Clean Energy Fund has been committed to or earmarked for renewable and clean energy system projects and research related to marine energy, smart grid, wind, energy storage, bioenergy, geothermal energy in the North, and community energy systems.

The Clean Energy Fund expenditures for the 2009–2010 fiscal year were approximately $30 million. Of that, $6 million was allocated to energy demonstration projects, which will contribute directly and indirectly to improved energy efficiency and the integration of renewable energy sources in Canada.

Key 2009–2010 Achievements

- Nineteen demonstration projects in renewable energy and clean energy technologies were announced in 2009–2010. These projects for renewable and clean energy systems will demonstrate marine energy, smart grid, wind, energy storage, bioenergy, geothermal energy in the North, and community energy systems.

For more information:

nrcan.gc.ca/eneene/science/renren-eng.php

CLEAN ENERGY SYSTEMS FOR BUILDINGS AND COMMUNITIES

Objective

To develop, demonstrate and promote – in domestic and foreign markets – technologies, practical decision-making tools, processes, codes, standards and best practices that help communities select more efficient and cost-effective energy, waste and water technologies and design solutions to support a sustainable energy future based on reduced energy consumption and GHG emissions.

Description

CanmetENERGY plays a leadership role in the R,D&D of energy-efficient and renewable energy technologies for houses, buildings and communities by

- fostering the commercialization of new technologies
- identifying and developing opportunities for the integration of energy efficiency and renewable energy technologies
- developing infrastructure to support innovation, such as codes, policies and standards
- developing linkages between utilities, industry and academia
- supporting training and education
- disseminating results and findings
- facilitating the export of Canadian technologies to international markets
- engaging in international co-operation

Specific work includes the development of innovative technologies, particularly integrated systems, design, modelling and analysis tools and integrated design approaches, such as building energy simulation software, making it possible to achieve greater energy efficiency to be implemented at minimal incremental costs. CanmetENERGY develops, distributes and supports building energy simulation software for the Canadian construction industry and Government of Canada ecoACTION programs.

CanmetENERGY is active in conceiving, developing and optimizing energy-efficient space and water heating, ventilation, air-conditioning and refrigeration technologies, thermal storage systems and micro co-generation systems through, for example, standards development, energy efficiency labelling, heat recovery systems, combined heat and power and energy conversion and storage systems, integration of technologies and adaptation to the Canadian context.

CanmetENERGY assists in increasing the use of solar thermal and solar photovoltaic (PV) energy technologies in Canada by developing technologies, standards, policies and programs to create a Canadian-based, globally competitive solar industry. Other work includes community energy systems, daylighting, intelligent building control and operation systems, and the commissioning/recommissioning of buildings.

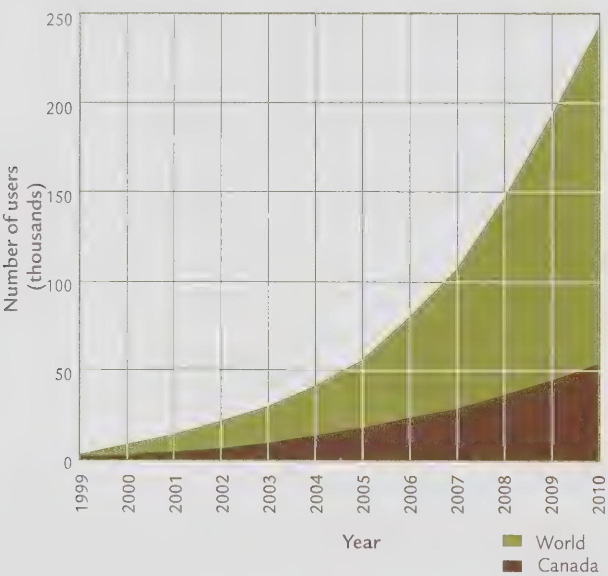
CanmetENERGY's partnerships with industry help to build advanced residential and commercial buildings that incorporate a wide array of innovative technologies and consume significantly less energy than their conventional counterparts. Under cost-sharing arrangements to accelerate the development and commercialization of a new generation of advanced and energy-efficient technologies, CanmetENERGY is helping the Canadian residential and commercial building industry produce some of the most environmentally advanced structures on the planet.

Key 2009–2010 Achievements

- CanmetENERGY increased the number of users of the RETScreen®[8] Clean Energy Project Analysis Software to more than 242 000 people in 222 countries, adding an average of 1000 new users every week (see Figure 4-1). More than 250 colleges and universities worldwide are now using RETScreen for education. As well, RETScreen was selected for several external awards, including the Summit Award for Leadership in Green Procurement (recipient), the Leadership Award at the Euromoney and Ernst & Young Global Renewable Energy Awards (finalist), and the Technology and Innovation Application Award at the GLOBE Awards for Environmental Excellence (finalist).

FIGURE 4-1

RETScreen Software: Cumulative Growth of User Base



Source: NRCan/RETScreen Customer Database.

- The DABO™ software developed by CanmetENERGY helped reduce building energy consumption at the Palais des congrès de Montréal by 10 percent in 2008–2009 and 13 percent in 2009–2010. DABO is a fault detection and diagnosis, performance analysis and documented history creation software application. This continuous building optimization program adds intelligence and memory to the building automation system. IFCS was selected as the commercial partner for licensing DABO and distributing it in Canada, Europe and China. Several projects to introduce DABO commercially are under development.

- North America's first solar seasonal storage community is meeting 80 percent of space heating needs with solar energy in its third year of operation. This milestone at the Drake Landing Solar Community in Okotoks, Alberta, is the highest performance level achieved anywhere in the world. This significant achievement gives confidence that the overall goal of more than 90 percent of heating needs being met by solar energy by year five is achievable.

- The Local Energy Efficiency Partnership™ (LEEP) is a process that enables builders to determine which new energy-efficient and renewable technologies best fit their production homes. CanmetENERGY and EnerQuality are expanding the pilot project of the LEEP process in four Ontario cities. The project will produce 40 demonstration homes within two years. CanmetENERGY is further developing the technology information for the LEEP processes so that each is tailored to the interests of the particular region.

- CanmetENERGY is examining the system performance of an innovative cold climate air-source heat pump. The project will monitor the long-term operation of the ACADIA™ pump from Hallowell International under a variety of climatic conditions. In particular, the project will track its performance at lower outdoor ambient temperatures than those currently considered practical for conventional pumps. The results of this work will help revise the heat pump performance standard.

[8] RETScreen is a registered trademark of Her Majesty the Queen in Right of Canada as represented by the Minister of Natural Resources.

- CanmetENERGY and its partners – Smart Growth on the Ground and the City of Prince George, British Columbia – completed extensive testing of an energy mapping methodology that will allow communities across Canada to assess their GHG reduction capacity. The technique developed included input from municipal, utility, provincial and federal databases to characterize the energy consumption patterns of the city.

- CanmetENERGY and its partners – Concordia University, the Canadian Solar Buildings Research Network, and Day4 Energy Inc. and Conserval Engineering, Inc. from the Canadian solar industry – designed and installed a combined solar power and heat generation system on a new building at Concordia's headquarters in Montréal. Day4 Energy supplies PV panels, and Conserval Engineering supplies the SolarWall®. The integrated 24.5-kilowatt-peak (kWp) PV panels and the 76 kWp of heat by fresh air solar-heating with the SolarWall cover approximately the top two floors of the building's south-facing façade. This demonstration in a commercial building showcases innovative means by which buildings of the future could produce energy for their own use, thereby reducing their demand on the electricity grid.

For more information:

canmetenergy.nrcan.gc.ca/eng/buildings_communities.html

CLEAN ELECTRIC POWER GENERATION

Objective

To develop and apply technologies for renewable electricity production and for cleaner power generation from fossil fuels, with the goal of increasing efficiency and achieving the reduction and, ultimately, the elimination of emissions of acid rain precursors, GHGs, particulates and identified priority substances, such as mercury, trace elements and organic compounds.

Description

CanmetENERGY's work on clean electric power generation focuses on improving the economics and efficiency of renewable energy technologies, including wind energy, solar power, small and low-head hydro, marine energy and energy storage.

CanmetENERGY's S&T supports the growth of the renewable energy industry in Canada by

- fostering the development of new technologies
- identifying and developing opportunities for building a « smart » power grid of renewable energy
- developing infrastructure to support innovation, such as codes, policies and standards
- developing linkages between utilities, industry and academia
- conducting nationwide resource assessments and mapping

CanmetENERGY also focuses on improving the performance of, and reducing emissions from, existing fossil fuel power plants. Moreover, it focuses on developing new advanced cycles for the conversion of fossil fuels to electricity with complete or near-complete capture and elimination of carbon dioxide (CO_2) and other emissions. Additional research includes work on issues associated with the transport and storage of CO_2. Through advanced tools and technologies, CanmetENERGY assists major industrial energy consumers in reducing the energy intensity of their operations and in reducing GHG emissions and emissions of other air pollutants, while enhancing competitiveness and profitability.

CanmetENERGY's work on emerging technologies in clean power includes new forms of power generation, such as wind, solar photovoltaics, small

hydro, marine, natural gas combined-cycle plants and advanced fluidized bed combustion. Significant R&D also focuses on CO_2-neutral combustion systems, CO_2 sequestration, CO_2 injection for enhanced oil recovery, advanced power generation cycles, clean coal technologies and distributed energy resources. CanmetENERGY also conducts leading-edge work in the burgeoning priority area of decentralized energy resources, where renewable energy sources are becoming more localized and integrated into the main power grid.

CanmetENERGY:

- addresses the technical, institutional and regulatory barriers to clean power by promoting power grid integration, developing standards, generating knowledge and transferring important information to Canadian decision-makers
- provides stakeholders with the necessary information to make informed decisions, and coordinates various research projects
- participates in international committees that establish standards and codes
- develops and hosts workshops and conferences
- develops publications and produces training tools
- capitalizes on its sector expertise by carrying out projects in collaboration with key research consortia, including industry, universities, research groups, public services and other departments and governments

Key 2009–2010 Achievements

- CanmetENERGY collaborated with the Xeni Gwet'in First Nation in the design and demonstration of solar PV "mini-grid" systems in a remote community in British Columbia. This project evaluated the benefits of three key improvements: installing PV systems on six houses (totalling 27 kilowatts [kW]), replacing a 90-kW generator with a 30-kW unit and installing a switch to control commercial and institutional electricity loads. The annual savings in diesel fuel was 26 000 litres compared with the reference year – a reduction of 25 percent in fuel and 73 tonnes (t) of GHG emissions.
- A nickel mining and processing company is carrying out an in-plant trial of an energy efficiency and emissions control strategy, jointly developed with CanmetENERGY. The new process is expected to reduce electricity needs by 14 percent (from 43 megawatts [MW] to 37 MW) and reduce petroleum coke consumption by 25 percent (from 4 t per hour (t/hr) to 3 t/hr). As a result, the direct and indirect reduction of CO_2 emissions is expected to be 120 kilotonnes (kt) per year. In addition, the new process is expected to reduce sulphur dioxide emissions by 20 kt per year, which makes a $300-million scrubbing treatment unnecessary.
- Oxyfuel fluidized bed combustion (FBC) units were developed at CanmetENERGY to examine oxyfuel firing in FBC systems. The bench-scale units are the first and the pilot-scale units the largest units built to date that demonstrate oxyfuel FBC technology with flue gas recycling. This technology can produce a pure CO_2 stream for capture and storage while burning a wide range of carbon-based fuels. Foster Wheeler Canada Ltd. is using the pilot-scale unit for fuel evaluation as a prelude to the company building a 300-MW electrical commercial scale demonstration unit.
- CanmetENERGY is developing a technology for hot scrubbing CO_2 for carbon capture and storage to replace amine scrubbing, thus reducing the energy penalty of CO_2 removal from power plants. CanmetENERGY is the first to demonstrate the technology experimentally. It also has developed several new methods of improving sorbent performance for CO_2 removal and a novel sorbent using a unique and inexpensive pelletization

technology that has shown the best performance so far reported in the literature.

- CanmetENERGY is leading the development of marine energy standards as Chair of Technical Committee (TC) 114. This committee was established by the International Electrotechnical Commission (IEC) and was mandated to produce global standards for these technologies. CanmetENERGY is leading the development of a technical specification that will provide uniform terminology for this sector. The standards developed through the IEC serve as a basis for national standardization. Active participation by members from CanmetENERGY in IEC TC 114 allows Canada to be at the forefront of standards development for this industry.

- CanmetENERGY, in co-operation with Core Energy Technologies, Inc. and Ontario's electrical and gas equipment approval agencies, installed a Stirling engine micro-cogeneration unit in an Ottawa area home, as a showcase and pilot testing opportunity. The unit is fuelled by natural gas and provides space heating and domestic hot water production while generating 1 kW of grid-tied electrical power. This technology is being adapted to also provide backup power for critical electrical loads during emergency power outages. CanmetENERGY has created new electrical testing capacity for the integration and evaluation of such systems under closely controlled laboratory conditions, which will lead to a better understanding of how to optimize micro-cogeneration products for the Canadian marketplace.

- CanmetENERGY cooperated with the Canadian Standards Association (CSA) in the adoption and publication of two PV module performance standards: CAN/CSA-C61215:08 is a design qualification standard for crystalline silicon PV modules and CAN/CSA-C61646:10 is the equivalent for thin film PV modules. Thin film technologies, a second generation of PV modules, are gaining a larger share of the PV market. Adopting these two international standards provides a technical basis for the design certification of PV modules sold in Canada and ensures the availability of high-quality PV modules for the Canadian market. CanmetENERGY chairs the Canadian national committee to the IEC for solar PV energy with an objective of ensuring harmonization of standards requirements at a global level.

For more information:

canmetenergy.nrcan.gc.ca/eng/clean_fossils_fuels.html

canmetenergy.nrcan.gc.ca/eng/renewables.html

CLEAN ENERGY SYSTEMS FOR INDUSTRY

Objective

To identify, encourage and support the development and application of leading-edge, energy-efficient and environmentally responsible processes, practices, products, systems and equipment in Canadian industry to improve its energy efficiency, productivity, competitiveness and profitability, while reducing GHG emissions and other environmental impacts.

Description

CanmetENERGY works with industry to co-manage and share the costs of development and commercialization of a range of technologies, including process integration, learning-based expert systems, combustion systems and controls, manufacturing processes, and environmentally friendly and energy-efficient processes for energy-intensive industries. CanmetENERGY's S&T in the industry sector focuses on plant-wide industrial process analysis techniques and advanced process control systems that identify and correct inefficiencies in plant operation and design while taking into account energy, economic and environmental aspects.

CanmetENERGY's S&T also includes the development and testing of semi-pilot-scale plants, pilot plants, prototypes and full-scale field trials. This research evaluates operating performance, energy efficiency and environmental impacts and emerging concepts in chemical and energy conversion, including hydrogen production from hydrocarbon and renewable sources. In addition, CanmetENERGY disseminates technical information to encourage adoption of these techniques and practices in targeted energy intensive sectors of Canadian industry.

CanmetENERGY clients are from a variety of industries, including pulp and paper, gas, oil upgrading and refining, petrochemicals, engine manufacturing, steel, chemicals, food and drink, solid wood, waste oil recycling and rendering, and specialty ceramic manufacturing. Its other clients are gas and electric utilities, equipment manufacturers and other governments.

Key 2009–2010 Achievements

- CanmetENERGY signed a three-year agreement with the Agence de l'efficacité énergétique to provide technical support for three demonstration projects in the food and beverage sector. The projects will demonstrate the benefits of integrating the refrigeration systems with the thermal energy system of the facilities and will foster the implementation of systems that use natural refrigerants instead of synthetic refrigerants. Additionally, the agreement requires that CanmetENERGY provide recommendations for an incentive program that targets the retrofit or installation of refrigeration systems in Quebec food-processing plants.

- In collaboration with the Agence de l'efficacité énergétique in Quebec, CanmetENERGY delivered the first Canadian advanced training session on heat integration of industrial processes to engineering firms, consultants, utilities and industries. Participants also had the opportunity to familiarize themselves with the newly developed process integration software that identifies and evaluates the impact of heat recovery projects in small and medium-sized enterprises and in large industries. These activities are part of a multiyear capacity building program to improve energy efficiency in Quebec.

- CanmetENERGY signed a four-year research agreement with Institut de recherche d'Hydro-Québec to develop a systematic approach to identify and recover energy from waste heat in industry. The main objective of this project is to develop a decision-making tool for the selection of waste heat recovery and upgrading solutions. The agreement also includes the development of advanced technologies such as heat pump and power production cycles, as well as a full-scale demonstration project at an industrial site. The recovery of energy from waste heat represents one of the greatest opportunities for reducing energy use and GHG emissions in industry.

For more information:

canmetenergy.nrcan.gc.ca/eng/industrial_processes.html

ENVIRONMENTALLY SUSTAINABLE OIL AND GAS

Objective

To provide S&T for the continued, secure supply of affordable, cleaner and more efficient fossil fuels, with little or no adverse environmental impact on GHG and Criteria Air Contaminant (CAC) emissions, and thereby help resolve oil sands environmental issues (including water) and clean air issues for the upstream oil and gas industry.

Description

CanmetENERGY conducts fundamental and applied research to develop knowledge and implement leading-edge technologies for the oil

sands sector. Knowledge gained is used to inform energy policy development and industry decisions that will improve the quality of life for Canadians.

CanmetENERGY fosters innovation in oil sands and heavy oil technology through activities ranging from fundamental science to commercial-scale technical support. CanmetENERGY's strength lies in its staff's fundamental understanding of the chemistry, physics and engineering of oil sands and heavy oil processes, coupled with sophisticated analytical instrumentation and pilot-scale units providing proof of concept for technologies.

S&T is a key tool used by NRCan to make significant progress toward meeting its water and tailings, GHG and other air emissions challenges in the oil and gas sector. Major improvements need to be made in the entire process chain of oil sands and heavy oil development, from the initial extraction to the production of petroleum products.

CanmetENERGY's international client base and partnerships with provincial and territorial governments, industry and academia ensure that the best available technologies in the world can be applied to the resource. Its partnerships also ensure there are strong synergies and fast-track deployment of new technologies, innovations and knowledge dissemination.

Key 2009–2010 Achievements

- CanmetENERGY is leading the research in developing monitoring technologies and protocols to quantify total particulate matter (PM) and the black carbon fraction from upstream oil and gas industry flares. PM, in particular the black carbon fraction of the total PM, is believed to be a highly potent source of GHG emissions. Early results from this research have been recognized internationally by the World Bank Global Gas Flaring Reduction partnership, the International Methane to Markets Partnership and the Arctic Council.
- CanmetENERGY worked with Syncrude Canada Ltd. to demonstrate a new dry stackable tailings technology known as rim ditching. Preliminary results from this large pilot test (80 000 cubic metres) are very promising. This method would be another way of managing oil sands fine tailings by decreasing the amount of water that is trapped in the pore space of fine tailings. After this water is removed, it can be recycled back to the process, thereby reducing the volume of fresh water required from the Athabasca River.
- CanmetENERGY identified silica-organic compounds in process water and their role in causing problems in recycling process water for in situ operations. This work was related to a major project for a steam-assisted gravity drainage operation that was investigating issues with its process water. Because in situ production is becoming the more prominent process, it is essential to understand the chemistry associated with recycling process water to reduce the demand on water resources.
- NRCan's Horizontal Task Team on Water completed its report on building a competitive advantage through sustainable water use, a freshwater strategy for the Department. This report outlines NRCan's recommended policy for issues about water that need to be addressed. This report gives NRCan guidance to focus research and policy development on water issues.
- CanmetENERGY and United States' national laboratories analysed the chemistry of diesel fuels and fuel blends. Fuel chemistry was assessed to determine its compatibility with advanced engines designed to produce no nitrogen oxide and PM emissions with maximum efficiency. CanmetENERGY worked with the Fuels for Advanced Combustion Engines working group within the Coordinating Research Council to examine fuels and combustion interactions.

For more information:

canmetenergy.nrcan.gc.ca/eng/clean_fossils_fuels.html

CLEAN TRANSPORTATION ENERGY

Objective

To develop and deploy, in partnership with industry, academia and the provinces and territories, leading-edge hydrogen, fuel cell and transportation energy technologies that reduce GHG emissions and minimize urban air pollution.

Description

CanmetENERGY works with stakeholders in domestic and international hydrogen and transportation industries. These industries include original equipment manufacturers, industry associations, fleet managers, transit authorities, utilities, provincial and territorial governments, research organizations, universities, other federal departments, the U.S. Department of Energy, the International Energy Agency (IEA) and the International Partnership for the Hydrogen Economy. Together, in these partnerships, projects are well leveraged – typically at a 50:50 ratio.

Transportation research, development and deployment activities at CanmetENERGY are grouped into three principal technology areas: hydrogen and fuel cells, hybrid and electric vehicles, and advanced fuels and technologies. All three technology areas are highly involved in domestic and international outreach, and safety, codes and standards for technology adaption and integration.

Since the early 1980s, CanmetENERGY's partnerships with industry have been playing a significant role in establishing Canada as a world leader in fuel cell and hydrogen-refuelling technologies.

Today near-term accomplishments are being made in the transportation and materials handling sectors. R&D in production, storage and utilization continue to lower costs and improve the performance of the hydrogen technologies.

Hydrogen fuelling stations and hydrogen-powered forklifts, airport baggage-tuggers, personal vehicles and shuttle buses continue to be deployed across Canada. In addition to vehicles and fuelling stations, developments in waste hydrogen capture and purification, production, distribution and storage are building the hydrogen infrastructure.

As well, applications in markets outside the transportation sector are being realized, such as micro fuel cells/portable applications (e.g. laptops and cellular phones) and stationary applications (e.g. off-grid and backup power for computers and buildings).

Electricity as an alternative transportation fuel is also becoming a near-term reality for Canada. Hybrid and electric vehicle technologies offer energy-saving advantages over current vehicle technologies that run solely on conventional fuels, such as gasoline or diesel.

CanmetENERGY is involved in R&D of on-board energy-storage and power systems, such as batteries and fuel cells. As the Government of Canada's lead, CanmetENERGY plays a significant role in coordinating and reviewing technical input from many private and public partners for the Canadian Electric Vehicle Technology Roadmap (evTRM).

Advanced fuels and technologies encompass all fuels and technologies in addition to hydrogen and fuel cells and hybrid and electric vehicles – examples are biodiesel, natural gas and ethanol. CanmetENERGY supports R&D for testing advanced fuels and fuel usage, as well as engine performance and components.

This area of R&D is serving to strengthen a Canadian industry that is now exporting commercial products. International collaborative efforts are helping to leverage Canada's research funding – particularly for the evaluation of fuels and hardware performance and in developing standards.

Key 2009–2010 Achievements

Research and Development

- CanmetENERGY partnered with the Canadian electric vehicle industry to produce an evTRM, published in January 2010. The evTRM identified strategic initiatives needed to support the implementation of electric vehicles on Canadian roads. An interdepartmental working group on electric mobility was formed to focus Government of Canada R&D efforts.

- Humidification is an important and delicate function of fuel cell performance. In fiscal year 2009–2010, CanmetENERGY supported research at dPoint Technologies Inc. to develop a fuel cell humidifier that uses a proton exchange membrane. This new membrane reduces the cost of humidifiers for 5-kW fuel cells from $2,500 to $60. More than 65 fuel cell companies in 15 countries are using this new low-cost humidifier.

- CanmetENERGY's hydrogen and fuel cell laboratory in Ottawa, Ontario, processed and characterized new materials for fuel cells and new nanomaterials for hydrogen storage. The two-year-old laboratory provides research expertise to external partners and access to unique facilities to meet joint technical targets. Canadian partners include Vale, the University of Waterloo, the University of Calgary and the NSERC Hydrogen Canada (H2CAN) Strategic Research Network supported by the Natural Sciences and Engineering Research Council of Canada (NSERC).

- In 2009, CanmetENERGY began coordinating a project on the life-cycle analysis of alternative fuels and technologies for urban transit buses, in conjunction with the IEA and Environment Canada. The project examines the environmental performance and ownership costs of various technology options. The resulting data will help transit authorities make decisions about alternative fuel and technology purchases and use.

Demonstrations

- In 2010, the five Ford Focus fuel cell vehicles of the Vancouver Fuel Cell Vehicle Program in British Columbia completed five years of operation and the fleet exceeded 350 000 kilometres (km). One of the vehicles exceeded 95 000 km, and none of the vehicles have had major component failures.

- The Canadian airport hydrogen project, the largest multiapplication hydrogen and fuel cell demonstration project in Canada, was launched in 2009. The project is located at the Pierre Elliot Trudeau International Airport in Montréal, Quebec, and at the Vancouver International Airport in Richmond, British Columbia. It will demonstrate and field test hydrogen technologies, including portable, mobile and stationary applications, as well as hydrogen fuelling infrastructure.

- In 2009, CanmetENERGY maintained involvement in demonstration projects under the National Renewable Diesel Demonstration Initiative (NRDDI). The NRDDI supports the mandate proposed by the Government of Canada of a 2 percent annual average renewable diesel content in the Canadian diesel pool by 2012. These projects covered the use of various biodiesel blends in on-road heavy-duty trucks, off-road equipment in forestry and construction, marine engines and rail agricultural equipment, as well as in stationary furnaces and electricity generators.

For more information:

canmetenergy.nrcan.gc.ca/eng/transportation.html

SUSTAINABLE BIOENERGY

Objective

To assist Canadian industry in the R,D&D of bioenergy technologies, thereby increasing the production and use of bioenergy, which generates environmental and economic benefits.

Description

CanmetENERGY supports the R,D&D of bioenergy technology through cost-shared agreements, promotes bioenergy as a renewable and sustainable energy source, advocates the need for proper policies and programs relating to bioenergy, and raises the public's and policy-makers' awareness of the benefits of bioenergy.

CanmetENERGY's biomass energy conversion technology expertise covers the following main processes:

- combustion – converting forestry, agricultural and municipal residues into heat and power under environmentally sound conditions
- gasification – converting forestry, agricultural and municipal residues into syngas
- pyrolysis – converting forestry and agricultural residues into bio-oils and value-added products
- fermentation – converting the starch and cellulose components in biomass into bio-ethanol
- transesterification – converting a variety of new and used vegetable oils, tallow and yellow grease into bio-diesel
- anaerobic digestion – converting manures and food-processing and municipal wastes into methane-rich biogas

Activities focus on improving the reliability and lowering the cost of technologies, disseminating information on technology feasibility and economics to potential users, and helping industry demonstrate its products in domestic and foreign markets.

Initiatives include R,D&D, technical and socio-economic studies, end-use demonstrations and testing, feasibility studies, process analysis, verification, testing and improvement, standards development, emissions reductions, modelling, conference and workshop support, information dissemination, IEA collaboration and committees, stakeholder education, and standards development.

CanmetENERGY plays a leadership role in the Canadian Biomass Innovation Network, a multidepartmental working group formed to direct federal R&D on bioenergy and bioproducts. Clients include the agricultural and forestry sectors (biomass producers and bioenergy consumers), municipalities and industrial partners.

Key 2009–2010 Achievements

- There is no mature foundation of standard practices for using biomass fuels for power generation. With funding from NRCan, Ontario Power Generation carried out an extensive review of global utility industry experience and global standards regarding process safety and industrial hygiene. The review investigated issues about the safe storage and handling of biomass, identified process safety and industrial hygiene risks and recommended mitigating actions and safety requirements.
- CanmetENERGY developed a pyrolysis project under the U.S.-Canada Clean Energy Dialogue, which reflects the strong interest of both countries in this technology area. The overall objective of this collaboration is to improve the potential for using the biomass pyrolysis pathway to generate biofuels for transport and stationary uses and for biorefinery applications.
- In an NRCan-supported project, Nexterra Systems Corp. completed the construction and commissioning of a first-of-its-kind project in the Kruger Products tissue mill in New Westminster,

British Columbia. This demonstration project was the critical step in commercializing the direct-fired gasification technology application for boilers and is expected to be replicated by leaders in the North American forest industry.

- Nexterra Systems Corp. received the Sustainability Champion Award from the Vancouver Organizing Committee for the 2010 Olympic and Paralympic Winter Games. The award was for Nexterra's leadership and contribution in making sustainability an integral part of the 2010 Olympics through strategic advice and support for the carbon offset program. Nexterra has acknowledged that it could not have achieved these successes without the support of NRCan and others over the years.

- CanmetENERGY led the collaboration among industry, government and academic stakeholders required to provide accurate, highly technical information to develop an ASTM International standard for pyrolysis oil. This will be the first worldwide standard for pyrolysis oil.

- CanmetENERGY supported the revision of the new CSA standard B415.1-10, Performance testing of solid-fuel-burning heating appliances. Improvements to the new version include stricter emission rates, the inclusion of appliances not covered previously (central heating furnaces and hydronic boilers) and the incorporation of alternative efficiency measurements.

- PlanET Biogas Solutions of St. Catharines, Ontario, designed, engineered and optimized two full-scale anerobic digestion systems to test the digestion of various agriculture and agri-food residues.

- In collaboration with the Wood Pellet Association of Canada, CanmetENERGY provided funding and technical expertise to develop *The Pellet Handbook*. The aim of this IEA-led activity is to contribute to pellet use within the energy sector. Canada has unique experience and expertise in pellet production, handling, storage and transportation.

For more information:

canmetenergy.nrcan.gc.ca/eng/bioenergy.html

CANADIAN BIOMASS INNOVATION NETWORK

Objective

To develop sustainable and cost-effective technologies in bioenergy, biofuels and industrial bioprocesses for market acceptance while utilizing biomass resources in a sustainable and responsible way.

Description

The Canadian Biomass Innovation Network (CBIN) supports strategic R&D in bioenergy, biofuels, bioproducts and industrial bioprocesses to reduce fossil fuel energy consumption, directly or indirectly reduce GHG and CAC emissions, diversify the energy supply and seed the development of Canada's bio-based economy.

CBIN is a horizontal program developed and managed by five departments: Agriculture and Agri-Food Canada, Environment Canada, Industry Canada, National Research Council Canada and NRCan. CBIN coordinates and manages two federal government bio-based R&D initiatives:

- the PERD Bio-Based Energy Systems and Technologies program ($3.0 million in 2009–2010)

- the ecoENERGY Technology Initiative Bio-Based Energy Systems ($2.1 million in 2009–2010)

Key 2009–2010 Achievements

- A standard was developed for residential wood heating appliances: CSA B415.1-10, Performance testing of solid-fuel-burning heating appliances. The test results of the four wood-heating appliances were incorporated into recommendations for the standard. The standard is now available. The revised standard is a significant step toward regulations for residential wood-heating appliances.
- The development of an ASTM International standard for pyrolysis oil (ASTM D7544-09) was a significant development. Previously, there were no worldwide standards for pyrolysis oil. Significant co-operation was required among industry, government and academic stakeholders. This specification covers a pyrolysis liquid biofuel produced from biomass that is intended for use in industrial burners equipped to handle these types of fuels.
- A pilot anaerobic digestion (AD) mobile unit was operated for six months at La Pinière Wastewater Treatment Plant in Laval, Quebec, to treat municipal wastewater excess sludge. This pilot demonstrated the applicability of AD to municipal biosolids, the validation of AD at the pilot scale and the development of a high-impact partnership with a municipal government. The demonstration proved the valorization of organic waste into renewable energy, with potential for reduction of GHGs. The research estimated that the insertion of AD in the current chain of sludge treatment at La Pinière could potentially reduce more than 10 t of organic solids per day, generate 5250 normal cubic metres of gas per day (Nm^3/d) or 3150 normal cubic metres of methane per day (Nm^3CH_4/d) of biogas and reduce GHG emissions by 4000 t CO_2 equivalent per year.
- A new third-generation bio-baler developed in 2009 harvested willow in plantations at a rate of 30 to 40 bales an hour – a significant improvement over the first generation bio-baler. This new harvest rate corresponds to a range of 14 to 18 t of fresh crop per hectare (ha) (7 to 9 t dry matter/ha). The machine is robust and may soon compete economically with modified self-propelled forage harvesters, which are the only commercial machines used to harvest willow from plantations in the form of wood chips.

For more information:

www.cbin.gc.ca

CHAPTER 5

Renewable Energy

RENEWABLE ENERGY USE

In 2008, renewable sources accounted for more than 62 percent of Canadian installed electricity capacity (see Table 5-1). Most of the renewable energy used in Canada comes from either hydroelectricity or thermal energy from biomass, such as wood-waste sources (see Table 5-2).

TABLE 5-1

Electricity Generation Capacity From Renewable Sources (Includes Hydroelectricity)

Year	Renewable electricity generation capacity (megawatts)	Total capacity (percent)	Percent change
1990	59 557	58.0	–
1991	61 116	58.0	3.0
1992	62 895	58.0	2.9
1993	63 114	56.0	0.3
1994	63 175	56.0	0.1
1995	66 542	57.0	5.3
1996	67 101	59.0	0.8
1997	68 202	61.0	1.6
1998	68 340	62.0	0.2
1999	68 614	61.8	0.4
2000	69 031	62.0	0.6
2001	68 845	61.2	-0.3
2002	71 032	61.8	3.2
2003	72 275	61.8	1.7
2004	72 947	60.4	0.9
2005	74 368	61.2	1.9
2006	75 812	61.3	1.9
2007	76 890	61.8	1.4
2008	78 371	62.4	1.9

Source: Statistics Canada, *Electric Power Generating Stations* (Cat. No. 57-206-XIB).

TABLE 5-2

Renewable Energy Technologies Used in Canada

Electricity – Commercial	Mechanical power
Hydroelectric dams	Wind water pumps
Tidal barrages	**Thermal energy**
In-stream current devices	Biomass (e.g. roundwood, pellets, wood chips)
Biomass (e.g. wood waste)	Ground-source heat pumps (i.e. earth energy)
Biogas (e.g. methane from landfill sites)	Solar air-heating systems
Wind turbines	Solar hot water systems
Photovoltaic systems	
Electricity – In development	**Transportation**
Wave systems	Biodiesel
Tidal systems	Ethanol from biomass

Hydroelectricity

Hydroelectricity is a renewable form of electricity generated from a system or technology that uses a mechanical method to capture and convert the potential energy of water.

Hydro is the main source of electricity in Canada, accounting for 60.4 percent of the electricity generated in 2008. Canada's hydro supply is dominated by large-scale projects that were developed by electric utilities. Of the 74 436 megawatts (MW) of installed hydro capacity, 3452 MW come from small hydro sites (capacity less than 50 MW), representing 2.7 percent of Canada's total installed electricity capacity. Significant potential remains for additional large and small run-of-river hydroelectric development in most provinces and territories.

Biomass

Biomass provides a renewable source of energy derived from the conversion of matter from living organisms or metabolic by-products. Canada has an abundant supply of many types of biomass, which is important for the production of energy, biofuels, materials and chemicals. The two largest sources of biomass supply in Canada are forestry and agricultural operations.

Biomass supply typically takes the following forms:

- forestry – mill or pulp-and-paper residues, black liquor from the pulping process, forest residue, forest management thinnings and short-rotation crops
- agriculture – agricultural crops, crop residue, processing residues, algae and aquatic biomass
- other organic waste – animal waste, such as manure from feed lots, municipal solid waste and industrial wastes

Approximately 4.3 percent of Canada's total energy supply comes from bioenergy, second only to hydro power (which generates 11.8 percent of Canada's energy). Most of the bioenergy produced is in the form of industrial process heat, electricity and residential space heating.

The pulp and paper and forestry industries are Canada's major producers and users of bioenergy. In 2008, 607 MW of biomass generating capacity came from spent pulping liquor used in the pulp and paper industry. This amount represents approximately 40 percent of the total biomass generating capacity, while 50 percent of the capacity (765 MW) came from wood refuse used in the forestry industry.

Heat and electricity produced by industry, electricity generated by independent power producers and residential wood heat are considered commonplace in Canada's energy mix. For example, approximately 3 million Canadian households use wood for home heating. Roundwood is typically used but alternatives include wood chips and pellets. Wood for home heating is usually burned in stand-alone wood stoves, wood furnaces with hot water or forced-air systems, fireplaces with advanced combustion inserts, high-efficiency fireplaces or high-thermal-mass masonry heaters.

Use of biogas and landfill gas (methane-rich gases that are derived from manure, animal processing wastes, other agricultural residues and municipal waste) for energy production is just emerging.

In 2008, the biomass installed capacity was 1516 MW, of which 9.5 percent was from landfill gas plants (109 MW) and municipal solid waste plants (35 MW). Approximately 200 million litres (L) of fuel ethanol are produced annually in Canada from cereal grain and corn. Biodiesel is also produced in small quantities, but production is increasing. Canada has the potential to increase its bioenergy production in a sustainable manner.

Earth Energy

As a result of the sun heating the surface of the planet, and because of the insulating qualities of the earth itself, the temperature 1 or 2 metres below the surface remains fairly constant – between 5°C and 10°C. This temperature is warmer than that of the air during the winter and cooler than that of the air in the summer.

Geothermal energy can be used as a heat source or sink for heating or cooling applications, such as ground-source heat pumps (GSHPs). GSHPs are electrical systems that use the relatively constant temperature of the ground to provide heating, cooling and hot water for homes and commercial buildings.

For this reason, a GSHP is known as an earth energy system (EES). During winter, EES installations remove heat from the earth using a liquid, typically an antifreeze solution or water that circulates within an underground loop. The EES then upgrades the heat with a conventional heat pump and transfers it to indoor space or the water-heating system. During summer, the system reverses this process to operate as an air conditioner. EES installations supply less than 1 percent of the market for space and water heating and cooling in Canada.

As of December 31, 2009, in Canada there were approximately 46 000 installed GSHPs with 555 megawatts of thermal energy (MW_{th}) of installed capacity producing an estimated

760 gigawatt-hours equivalent annually. In 2008, 15 000 GSHP units were installed in Canada. This compares with 9100 units installed in 2007 and 4217 units installed in 2006.

Wind Energy

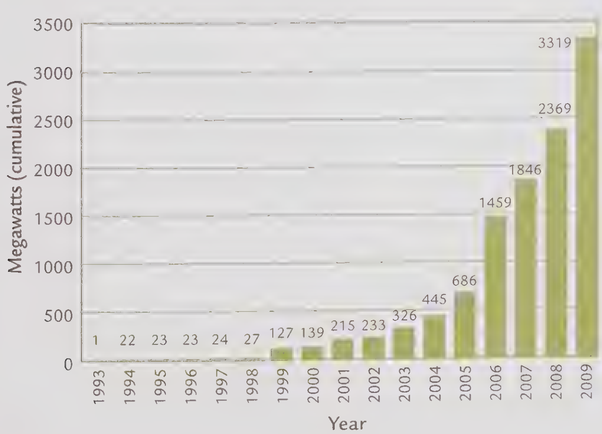
Wind turbines convert the kinetic energy of wind into electrical or mechanical energy. Canada's land mass and coastal waters combine to provide a wind resource with potential estimated at more than 100 000 MW.

As of December 31, 2009, 3319 MW of wind power had been installed in Canada. This makes Canada the 13th country that has reached the 1000-MW milestone and the country with the 12th-largest installed wind energy capacity.

The best year in terms of wind power installations was 2009, with 950 MW of new wind power generating capacity installed across the country, representing a 40 percent increase from the 2008 level (2369 MW) (see Figure 5.1). Proposals to build Canada's first offshore wind farms on submerged lands near British Columbia and in Lake Ontario are proceeding through the permitting stage. Federal and provincial policies continue to spur growth in the Canadian wind industry.

FIGURE 5-1

Canadian Wind Power Cumulative Capacity, 1993 to 2009



Source: Canadian Wind Energy Association.

Wind energy also provides mechanical power. Several thousand wind-powered water pumps are used throughout Canada, mostly in the Prairie provinces. As well, Canadians use small, residential-sized wind turbines to power cottages and remote houses.

Solar Energy

Three main technologies use energy from the sun:

- passive solar technologies – buildings are designed and located to maximize their reception of solar energy
- active solar thermal systems – solar radiation is converted into thermal energy for heating air or water in residential, commercial and industrial applications
- solar electric (photovoltaic [PV]) systems – solar radiation is used to produce electricity

The Canadian active solar thermal installed capacity in 2008 was 720 000 square metres (m^2), or approximately 500 MW_{th}. The domestic market increase has averaged 13 percent annually since 1998. In 2008, the solar thermal collector market in Canada was 139 159 m^2, more than twice the installations in 2007 (60 900 m^2), with revenues up 44 percent from the 2007 level. This is likely due to increased domestic sales of glazed and evacuated tube collectors and reduced sales of unglazed air heating collectors in this period.

Canada's PV power installed capacity reached 94.57 MW in 2009, compared with 32.72 MW in 2008. The grid-connected market accounts for 87 percent of the market in 2009, compared with only 33 percent in 2008. This significant growth was spurred primarily by two programs from the Government of Ontario: a renewable energy standard offer program launched in 2006 and the new feed-in tariff program launched in 2009. Out of the approximately 82 MW of grid-connected installed capacity in 2009, small, residential and building integrated solar PV systems represented 11 percent,

while three large ground-mounted utility-scale solar PV farms alone represented 76 percent.

Ocean Renewable Energy

Ocean renewable energy refers to the use of ocean waves, current and tides to generate electricity. Devices that capture ocean or tidal currents can also be deployed in rivers and streams.

Since 1984, Canada has had the only commercial tidal energy facility in North America – the 20-MW plant in Annapolis, Nova Scotia. However, like wave and current devices, the next generation of tidal power generators is in an early stage of development, and as yet no commercial facilities have been proposed.

Canada is well poised to become a leader in global technology development and deployment. Canadian technology developers are planning and testing devices, and several demonstration projects are underway.

PULP AND PAPER GREEN TRANSFORMATION PROGRAM

Objective

The Pulp and Paper Green Transformation Program (PPGTP) was created to fund green capital projects at Canadian pulp and paper mills, leading to improved environmental and commercial sustainability of the sector.

Description

The $1-billion PPGTP was launched in June 2009. It supports innovation and environmentally friendly investments in Canada's pulp and paper industry in such areas as energy efficiency and renewable energy production. In October 2009, credits were allocated to 24 companies, based on black liquor production ($0.16/L) at 38 pulp and paper mills. Companies have until March 31, 2012, to invest their credits at any of their Canadian pulp and paper mills in approved green capital projects that lead to measurable environmental benefits.

Key 2009–2010 Achievements

- Signed 10 contribution agreements with seven companies for close to $200 million, with approximately $49 million provided for 2009–2010.
- These agreements support the creation of approximately 60 MW of renewable electrical capacity.

For more information:

www.cfs.nrcan.gc.ca/subsite/pulp-paper-green-transformation

Natural Resources Canada carries out two initiatives to increase the use of renewable energy in Canada: ecoENERGY for Renewable Power and ecoENERGY for Renewable Heat. The two programs are outlined below.

ecoENERGY FOR RENEWABLE POWER

Objective

To encourage the production of 14.3 terawatt hours of electricity from low-impact renewable energy sources (about 4000 MW of new capacity), such as wind, hydro, biomass, solar PV and ocean energy, between April 1, 2007, and March 31, 2011.

Description

The ecoENERGY for Renewable Power program provides an incentive of one cent per kilowatt hour to an eligible low-impact renewable energy project for up to 10 years. Eligible recipients include businesses, institutions/organizations, independent power producers, public and private utilities, and co-operatives that install qualifying renewable power systems. Qualifying projects must have a total rated capacity of 1 MW or greater.

Key 2009–2010 Achievements

- As of March 31, 2010, 100 contribution agreements had been signed with proponents, representing about $1.4 billion in federal funding over 10 years and 4400 MW of renewable power capacity.
- After all 100 projects are commissioned, the expected greenhouse gas (GHG) emission reductions from full-year operations are expected to be about 6 megatonnes per year.

For more information:

ecoaction.gc.ca/ecorp

ecoENERGY FOR RENEWABLE HEAT

Objective

To increase the use of renewable energy technologies, develop thermal energy industry capacity and contribute to the reduction of harmful emissions. This four-year program was launched April 1, 2007.

Description

The ecoENERGY for Renewable Heat program supports renewable thermal technologies used for space heating and cooling and water heating, through a mix of deployment incentives, residential pilot projects and industry capacity-development funding:

- deployment incentive – providing a financial contribution to encourage the deployment of solar thermal units in the industrial, commercial and institutional sectors
- residential pilot projects – providing financial contributions to test, through collaborative ventures, various approaches to the large-scale deployment of solar water-heating units in the residential sector
- industry capacity-development – providing financial contributions to develop technology standards and certification processes for solar thermal technologies, human resources skills and tools and to provide public information for renewable thermal energy technologies

Key 2009–2010 Achievements

- Installed 297 solar thermal systems in the industrial, commercial and institutional sectors.
- Signed contribution agreements with 11 partners (utilities, developers and buyers' groups) to run pilot projects that will test large-scale methods to deploy solar-heated water in the residential sector. Under the pilot projects, up to 2000 solar water-heating systems will be installed in Canadian homes by 2011.
- Established a partnership with one provincial government, bringing the number of arrangements with provincial governments for complementary programs to three.
- Entered into partnerships with two renewable energy industry associations and two other groups to improve training and certification of solar and geoexchange industry professionals.
- Signed nine contribution agreements with companies for the certification of packaged solar domestic water-heating systems.
- The estimated GHG reductions from systems installed under the program during 2007–2008, 2008–2009 and 2009–2010 are 3.3, 5.1 and 8.0 kilotonnes (kt), respectively. The cumulative annual GHG reductions from the program from these installations are 16.4 kt.

For more information:

ecoaction.gc.ca/heat

CHAPTER 6
Co-operation

INTRODUCTION

This chapter describes Natural Resources Canada's (NRCan's) co-operation with provincial and territorial governments and internationally on efficiency and alternative energy (EAE) during the reporting period. Examples of program co-operation on specific EAE initiatives are included in the "Key Achievements" sections of earlier chapters.

Municipal governments and agencies participate in NRCan's EAE measures as clients (for training workshops, as recipients of financial incentives, etc.) and as partners (e.g. in idle-free projects). At the same time, NRCan participates in ventures led by municipal organizations, such as the Green Municipal Fund (see accompanying textbox), and by provincially and territorially regulated electricity utilities and provincially regulated natural gas utilities.

Several institutions in Canada address energy efficiency issues in broad terms, including the three data and analysis centres established by NRCan, the host universities and other partners. Their main objectives are to facilitate access to data on energy use in the industry, transportation and building sectors; monitor the quality of data; develop expert knowledge; and investigate methods of improving data collection and analysis. Since their establishment, these centres are also sponsored by various entities, including other federal departments, provincial government agencies, industry associations and energy supply utilities.

There are two national consultative bodies in the area of energy efficiency: the Steering Committee on Energy Efficiency (SCEE), established under the Council of Energy Ministers; and the Office of Energy Efficiency's (OEE's) National Advisory Council on Energy Efficiency (NACEE).

Green Municipal Fund

The Government of Canada endowed the Federation of Canadian Municipalities (FCM), a non-profit organization, with $550 million to establish the Green Municipal Fund (GMF) for the purpose of providing a long-term, sustainable source of funding for municipal governments and their partners. The GMF invests in plans, studies and projects that offer the best examples of municipal leadership in sustainable development and that other Canadian communities can replicate.

Under the GMF agreement, the Government of Canada (represented by NRCan and Environment Canada) participates in governance of this revolving fund, along with representatives from the public and private sectors, including municipal officials and technical experts, through a peer review committee and an advisory council.

The FCM board of directors approves projects in light of the council's recommendations. As of March 31, 2010, the GMF had approved more than $450 million for more than 800 sustainable community plans, feasibility studies, field tests and capital projects with the potential to leverage almost $3 billion of economic activity in approximately 400 Canadian communities. Actual environmental benefits include the reduction of an estimated 103 994 tonnes of carbon dioxide annually from 28 completed capital projects.

More details can be found in the *Green Municipal Fund Annual Report 2009–2010* at **fmv.fcm.ca/About_Us/Annual_Reports/**.

STEERING COMMITTEE ON ENERGY EFFICIENCY

In 2004, federal, provincial and territorial energy ministers established the SCEE and tasked it with establishing a coordinated, complementary agenda for energy efficiency in the built environment, industry and transportation sectors. The SCEE held four face-to-face meetings in the 2009–2010 fiscal year – in Winnipeg, Montréal, Ottawa and Toronto – with members representing the federal, provincial and territorial governments.

There are three working groups under the auspices of the SCEE. In 2007, the SCEE and its working groups contributed to the development of the Council of Energy Ministers' document *Moving Forward on Energy Efficiency in Canada: A Foundation for Action*.

Responding to Ministers' direction, the three SCEE working groups are continually undertaking actions to develop concrete energy efficiency initiatives based on the themes and ideas in *Moving Forward on Energy Efficiency in Canada*. These may be delivered by multiple jurisdictions and in conjunction with key stakeholders.

At the September 1, 2009, meeting of the Council of Energy Ministers, the efforts of these working groups culminated in the announcement of a series of tools for collaborative energy efficiency actions, namely:

- *On the Road to a Fuel-efficient Truck: A Guide for Purchasing Aerodynamics for Heavy-Duty Tractors and Trailers* – to provide truck owners and operators with the information to select, install, maintain and drive with aerodynamic devices that can be installed on heavy-duty trucks to reduce fuel use and greenhouse gas (GHG) emissions, as well as how to calculate expected fuel savings and return on investments
- *The Energy Management Information Systems (EMIS) Audit and Implementation Plan Manual and Tool* – to assist industrial facilities in better measuring and tracking energy use to help promote investing in energy efficiency through the proper use of an EMIS audit, preparing business cases and implementing systems to achieve long-term reductions in energy consumption per unit of production
- *Recommissioning Guide for Building Owners and Managers* – to provide education for sector clients and training for service providers on how existing building recommissioning can facilitate the optimal energy performance envisioned by updated building codes
- *Integrated Community Energy Solutions: A Roadmap for Action* – to provide a broad strategy to capitalize on synergies available at the community level to achieve improvements in energy performance and cuts to GHG emissions, as well as a menu of tools to complement existing sectoral energy efficiency strategies
- Formed in 2003, the Built Environment Working Group (formerly the Demand Side Management Working Group) has members representing NRCan, industry and all provinces and territories. Its subcommittees perform collaborative tasks in the following areas:
  - *National Energy Code for Buildings*
  - building energy benchmarking
  - commissioning and recommissioning of buildings
  - energy-efficient equipment
  - integrated community energy solutions
  - lower-income-household energy efficiency options
  - accelerated penetration of energy-efficient home retrofits
  - energy efficiency financing in the commercial/institutional sector
  - a positioning paper on energy efficiency
- The SCEE sponsored the formation of the Transportation Working Group on Energy

Efficiency (TWGEE) in 2005. Its mandate is to assess the status and enhance the alignment of transportation energy efficiency activities across federal, provincial and territorial jurisdictions and to investigate opportunities for further collaboration and new initiatives. The TWGEE comprises government officials from federal, provincial and territorial energy and transportation departments and ministries.

In the 2009–2010 fiscal year, TWGEE members collaborated to launch *On the Road to a Fuel-efficient Truck: A Guide for Purchasing Aerodynamics for Heavy-Duty Tractors and Trailers*, referenced above. Additionally, TWGEE members developed a best practices guide for developing idle-reduction programs, which was distributed to federal and provincial government partners, strengthening the cooperation, collaboration and alignment among jurisdictions on this issue. The TWGEE also undertook research studies that will be used to engage industry stakeholders on the issue of fuel-efficient tires and involve them in developing a framework that could be used in Canada to promote fuel-efficient tires to heavy-duty truck tire purchasers.

- The Industry Working Group on Energy Efficiency was formed in 2006. It promotes information exchange among industrial energy end-users and authorities, agencies, utilities and jurisdictions involved in the design, development and delivery of industrial energy efficiency programming in Canada.

  The working group launched Canada's involvement in developing the ISO[9] 50001 standard for Energy Management Systems Standard. In the 2009–2010 fiscal year, significant progress was made in addressing the scope, language and definition of the standard, energy performance indicators and the energy planning process. The standard is expected to be available in the 2011–2012 fiscal year. In support of the standard, three pilot workshops were undertaken with respect to the energy management information systems. These efforts have facilitated the development of a new EMIS Dollars to $ense Energy Management workshop to be launched in 2011–2012.

NATIONAL ADVISORY COUNCIL ON ENERGY EFFICIENCY

NACEE was created in April 1998 to assist the OEE as an innovative government organization by

- assessing and advising on the OEE's strategic approach to meeting federal policy objectives
- advising the OEE on its performance and business planning and reporting on progress
- considering issues related to accelerating growth in energy efficiency in the Canadian economy

NACEE membership is drawn from across Canada. It includes representatives from various levels of government, academia, economic sectors, energy utilities and advocacy groups. NACEE met twice during the 2009–2010 fiscal year.

FEDERAL-PROVINCIAL AND FEDERAL-TERRITORIAL CO-OPERATION

Interest continues to grow in energy efficiency as a means of maximizing the services obtained from Canada's existing energy supply capacity. In addition to general co-operation on energy efficiency, provincial and territorial governments helped to deliver or employ tools provided by federal EAE programs to reduce energy costs, address climate change, increase competitiveness, improve air quality and create economic opportunities. Coordination between the federal and provincial/territorial levels avoids duplication and ensures efficient program delivery.

All provinces and territories engage in energy efficiency activities and/or deliver energy efficiency programs in their jurisdictions. In some provinces and territories, specific organizations are mandated to promote energy efficiency.

---

[9] International Organization for Standardization.

Use of Federal EAE Program Tools by Utilities, Provinces and Territories

Provincial and territorial governments and utilities use federal EAE program tools to complement their own energy efficiency programs. Here are some examples:

- Homeowners in all regions of Canada, except one territory, were able to access both provincial/territorial and federal home retrofit programs through a single energy evaluation offered under ecoENERGY Retrofit – Homes. The ecoENERGY evaluation and its criteria are also used by these jurisdictions to determine eligibility for incentives.
- Canadians in most provinces and territories can benefit from rebates and sales tax exemptions on selected ENERGY STAR® qualified products. The ENERGY STAR Initiative in Canada is administered by the OEE and is used by a number of provinces and utilities as a qualifying criterion.
- NRCan's R-2000 Standard is used by utilities in Manitoba, New Brunswick and Nova Scotia as a qualifying criterion for incentives and rebates designed to encourage the construction of energy-efficient new homes.
- All the provincial and territorial bodies (with the exception of Nunavut) responsible for driver education use the Auto$mart Driver Education Kit, developed by the OEE, to educate young drivers on fuel efficiency. For example, Manitoba Public Insurance and the Province of Ontario have recently incorporated a component on fuel efficiency into their driver education curricula. Also, many provinces display the OEE's publications in their licensing bureaus.
- Similarly, for commercial drivers, four memoranda of understanding with provinces and territories were put in place in 2009–2010, with five more under negotiation. Under these agreements, the province or territory will begin to incorporate knowledge of fuel-efficient driving techniques as a requirement in commercial driver licensing for novice drivers. OEE's ecoENERGY for Fleets program will provide the educational and informational materials that are needed by the provinces, territories and driver educators to respond to this new requirement. This will ensure that new licensees in these jurisdictions are exposed to information on fuel-efficient driving practices as part of the licensing process and further encourage the uptake of program materials by driver education schools.
- The OEE works in co-operation with many provincial organizations, such as Conserve Nova Scotia, to fund and implement actions to reduce energy use and GHG emissions from personal vehicles by improving the buying, driving and maintenance practices of Canadians.

For example, one of the objectives of Alberta's Climate Change Central is to focus on information and action on energy efficiency and conservation in the province.

The Manitoba Hydro Power Smart program is widely recognized for its effective, user-friendly tools for homeowners, businesses and industry to boost energy efficiency and save significantly on energy costs.

The Ontario Power Authority's Conservation Bureau provides leadership in planning and coordinating measures for electricity conservation and load management.

The Yukon Energy Solutions Centre is a service and program delivery agency for federal and Yukon government programs on energy efficiency and green power.

Recently, there has been a greater focus on energy efficiency in the Maritime provinces, as evidenced by the work of three agencies: Efficiency NB, Conserve Nova Scotia and Prince Edward Island's Office of Energy Efficiency.

Other regional organizations of note are the Arctic Energy Alliance in the Northwest Territories and the Agence de l'efficacité énergétique du Québec.

The provinces have been promoting the use of renewable energy for electricity generation. They provide numerous incentives, including voluntary renewable energy targets, legislated renewable portfolio standards and the procurement of renewable energy through requests for proposals, standard offers and feed-in tariff programs.

The Building Energy Codes Collaborative

The Building Energy Codes Collaborative (BECC) is a federal-provincial-territorial committee supported by the Council of Energy Ministers, the SCEE and NRCan. BECC is made up of representatives from provincial/territorial code and energy ministries, departments and agencies; NRCan; and the Canadian Codes Centre. The objectives of BECC are as follows:

- provide a forum for provinces, territories and the Government of Canada to support the update, regulatory adoption and implementation of the *Model National Energy Code for Buildings* (MNECB), which is now called the *National Energy Code for Buildings* (NECB), by responsible authorities
- work in co-operation with the provinces and territories and the Canadian Commission on Building and Fire Codes toward a national consensus on establishing energy efficiency in the code process
- explore other regulatory and/or program instruments for increasing energy efficiency in new housing, including updating the NECB

NRCan and BECC prepared a business plan for updating the 1997 NECB and presented it to the Canadian Commission on Building and Fire Codes. Commission members unanimously approved the following motion at its annual meeting in Calgary in February 2007: ". . . that the updating of the MNECB as a progeny document based on the BECC Business Plan be approved."

NRCan then prepared and signed a memorandum of understanding (MOU) with the National Research Council Canada (NRC). NRCan is contributing up to $5 million over four years to support the technical development of the new code and is providing technical expertise to the NRC team tasked with developing national codes. The NRC launched the project, and the Standing Committee on Energy Efficiency in Buildings held its first meeting on updating the code in Ottawa in December 2007.

The updated NECB will be published by 2011 in an objective-based format. It will complement objective-based model national construction codes published in 2005.

Co-operation Agreements

NRCan's memorandum of agreement (MOA) on EAE with the Agence de l'efficacité énergétique du Québec provides for consultation and sharing of information between the two governments, the coordination of EAE activities in Quebec and the creation of opportunities for joint projects. Further, the management committee established under the MOA reviews policy and program developments, progress on joint program initiatives and areas for further co-operation. NRCan is working with the Agence de l'efficacité énergétique to deliver services under the ecoENERGY programs.

The MOA played a role in facilitating three activities in particular:

- management of the licensing agreement for local delivery of ecoENERGY Retrofit – Homes
- continued processing of payments by the OEE's Buildings Division for the former EnerGuide

for Existing Buildings and Commercial Building Incentive programs under a letter of co-operation (LOC) with the Agence de l'efficacité énergétique. Though the two programs are closed, payments, which can be made only when the client verifies that work has been completed, are still being processed.

- signing a three-year collaboration agreement with CanmetENERGY and the Agence de l'efficacité énergétique to help refrigerated facilities (ice and curling rinks, supermarkets, warehouses) in Quebec reduce their energy consumption and GHG emissions through the Programme d'optimisation en réfrigération (OPTER). This program is based on the CoolSolution approach developed by CanmetENERGY. CanmetENERGY provides technical support and training for consultants and decision-makers.

NRCan's LOC on energy efficiency and renewable energy with the Government of Yukon facilitates information sharing and the creation of opportunities for joint projects in Yukon. These projects include the Yukon Energy Solutions Centre in Whitehorse. The Centre provides access to technical services and programs for the Yukon population and undertakes outreach and public education activities.

NRCan works with the Office of the Fire Commissioner of Manitoba, a special operating agency of Manitoba Labour and Immigration, to engage Manitoba stakeholders in a review of the Energy Code Advisory Committee recommendations.

Manitoba is also consulting stakeholders on introducing water efficiency in the plumbing code and identifying barriers in the *Manitoba Building Code* to energy and water efficiency in buildings. The result will be a stakeholder consultation report provided to Manitoba's Minister of Labour and Immigration and Minister of Science, Technology, Energy and Mines.

Sustainable Development Technology Canada – NextGen Biofuels Fund™

The NextGen Biofuels Fund™ is a $500-million program scheduled to run from 2008 to 2017. Responsibility for the program is held jointly by NRCan and Environment Canada. The fund is managed under the auspices of Sustainable Development Technology Canada (SDTC).

The NextGen Biofuels Fund™ aims to facilitate the establishment of first-of-a-kind, large, demonstration-scale facilities for the production of next-generation biofuels and co-products in Canada; improve the sustainable development impacts arising from the production and use of biofuels; and encourage retention and growth of technology expertise and innovation capacity for the production of next-generation biofuels.

Next-generation renewable fuels are derived from non-traditional renewable feedstocks – such as forest biomass, fast-growing grasses and agricultural residues – and are produced with non-conventional conversion technologies. An eligible project must use feedstocks that are or could be representative of Canadian biomass, and the technology must have been demonstrated at the pre-commercial pilot scale. SDTC supports up to 40 percent of eligible project costs.

In 2009, SDTC approved funding for the detailed engineering phase of a large demonstration-scale cellulosic ethanol facility project. Based on the results, SDTC will decide whether to fund the construction phase of the project. SDTC is also assessing other projects for funding.

NRCan works with Ontario's Ministry of Small Business and Consumer Services, the Independent Electricity System Operator and local distribution companies to provide energy management training

to companies across Ontario through Dollars to $ense Energy Management workshops.

The Government of Canada promotes energy efficiency and renewable energy in Alberta by working with Climate Change Central, a non-profit corporation funded by several stakeholders, including the Government of Alberta.

NRCan works with Efficiency NB to facilitate the access for owners of small and medium-sized buildings to the ecoEnergy Retrofit – Small and Medium Organizations program.

Atlantic Energy Gateway

The Atlantic Energy Gateway (AEG) is a $4-million joint initiative of NRCan and the Atlantic Canada Opportunities Agency for facilitating co-operation among Atlantic provinces for the development of the region's clean energy resources.

In 2009, an AEG advisory committee of federal, provincial and utility members was formed. The committee oversees research and analysis that will provide insight into the challenges and opportunities involved in maximizing the benefits of developing clean energy in the Atlantic region.

INTERNATIONAL CO-OPERATION

NRCan co-operates with several international organizations and foreign governments in EAE program areas. Canada benefits from this co-operation by

- learning about improved ways of designing and delivering EAE programs to meet policy objectives
- working with others on the harmonization of energy efficiency tests and performance standards to reduce barriers to trade in energy-using products (in this regard, NRCan provides input, as requested, to Foreign Affairs and International Trade Canada on prospective free trade agreements and on technical barriers to trade)
- participating, along with other international partners, including the U.S. Department of Energy, in the development of ISO 50001, an Energy Management Standard that will help guide industry on best management practices and technical practices to reduce energy waste. Work on the standard started in the fall of 2008, and the expected release date is mid 2011.

International Energy Agency

The International Energy Agency (IEA), based in Paris, France, is an autonomous agency of the Organisation for Economic Co-operation and Development. The IEA runs a comprehensive program of energy co-operation among its 26 member countries, including Canada. IEA member governments have committed to sharing energy information, coordinating energy policies and co-operating on the development of national energy programs incorporating energy security, economic development and environmental protection. The IEA and its Governing Board are assisted in their work by several standing groups and special committees, which bring together energy specialists from member countries.

The Standing Group on Long-Term Co-operation (SLT) is the key committee on the policy side. The SLT analyses policies to promote conservation and the efficient use of energy, as well as measures to increase long-term energy security while protecting the environment. The SLT monitors energy developments in member countries and makes recommendations on energy policy through a regular series of individual country reviews, including the *Energy Policies of IEA Countries – Canada – 2009 Review*, which was released in April 2010. The SLT's Energy Efficiency Working Party (EEWP) provides advice on and direction to the IEA's work on specific energy efficiency issues. The OEE represents Canada on the EEWP. In 2009–2010, the IEA released a report card to the Group of Eight (G8) that recognized Canada as one of the top four IEA member countries that has fully or

partially implemented the IEA's recommendations on energy efficiency.

Canada's international energy research and development (R&D) objectives are mainly advanced through the IEA's working parties, implementing agreements, and experts groups that are under the Committee for Energy Research and Technology. Canada participates in 31 of the IEA's 40 implementing agreements on R&D collaboration programs. NRCan contributed $889,000 to IEA implementing agreements in 2009–2010. One such agreement is the IEA Implementing Agreement for a Co-operating Programme on Efficient Electrical End-Use Equipment (4E). This agreement brings together energy efficiency policy-makers from Asia, Europe and North America to encourage the use of more efficient appliances (e.g. solid state lighting, electric motor systems and standby power). Co-operation through implementing agreements has helped to accelerate technology development and set the stage for technology deployment in Canada, generating benefits that far outweigh the direct costs of collaboration.

Canada also co-operates with research centres in IEA member countries on several R&D and technology agreements and programs outside the IEA. NRCan, together with Foreign Affairs and International Trade Canada, facilitates R&D and commercial business ventures abroad by Canadian firms by undertaking a wide variety of activities. These activities include participating in various IEA tasks and supporting technical and trade-oriented workshops and conferences.

CanmetENERGY was named the operating agent of the new IEA Annex 54, "Integration of Micro-generation and other Energy Related Technologies in Buildings." The research program will focus on improved models of poly-generation and/or hybrid type micro-generation systems. The purpose is to better assess the application of these systems, to identify the impact on energy use and GHG emissions and to investigate the competitiveness of these micro-generation systems in relation to other technologies. Participants are from 14 countries in Europe, Asia, Japan and North America and represent 24 research organizations, academia and private companies.

Group of Eight

At the G8 Summit in 2007 in Heiligendamm, Germany, the leaders of the G8 countries and Brazil, China, India, Mexico and South Africa agreed to initiate a topic-driven dialogue under the "Heiligendamm Process." Working groups were formed around the process' four pillars, one of which was energy, with a special focus on energy efficiency. The Energy Working Group explored the common ground available for building international support for new ideas and approaches for increasing energy efficiency. It focused on energy security, development of a sustainable buildings network, energy efficiency in existing power plants, and alternative sources of energy and renewable energy. Canada served as co-chair with India. The Working Group held its final meeting in April 2009 and submitted its report to the Heiligendamm Dialogue Process Steering Committee. The Steering Committee summarized the reports of the four working groups and submitted its report and conclusions to the 2009 G8 Summit in Italy.

International Partnership for Energy Efficiency Cooperation

NRCan participated in the development of an agreement establishing the International Partnership for Energy Efficiency Cooperation (IPEEC). This agreement was formally signed by Canada and 11 other countries during the G8 Energy Ministers Meeting in May 2009. The partnership supports the on-going energy efficiency work of the participating countries and relevant international organizations. The IPEEC Executive Committee met in 2009 and 2010, and the Policy Committee first met 2010. A key component of the IPEEC framework is task groups that pursue projects that interest most, but not all, IPEEC

member countries. Canada contributed to the Sustainable Buildings Network Task Group and the Super-Efficient Equipment and Appliance Deployment Task Group.

Methane to Markets

CanmetENERGY represents Canada, in collaboration with the Environment Canada Climate Change International Branch, at the international Methane to Markets Partnership Steering Committee and co-chairs the Methane to Markets Oil and Gas Subcommittee with Mexico and Russia. CanmetENERGY-Devon R&D projects were showcased at the international Methane to Markets Partnership Expo in Delhi, India, on March 2–5, 2010. These domestic and international projects manage energy and emissions at oil and natural gas production and processing operations.

United Nations

RETScreen® International is managed under the leadership of NRCan's CanmetENERGY. The RETScreen Clean Energy Project Analysis software, provided free-of-charge, can be used worldwide to evaluate the energy production and savings, costs, emission reductions, financial viability and risk for various types of renewable energy and energy-efficient technologies. RETScreen is managed through cost- and task-shared collaborative ventures with other governments and multilateral organizations and with technical support from more than 350 experts representing industry, government and academia.

Key partners are the NASA Langley Research Center, the Renewable Energy and Energy Efficiency Partnership and the Energy Branch of the United Nations Environment Programme.

Asia-Pacific Economic Cooperation (APEC)

The OEE is a member of the APEC Expert Group on Energy Efficiency and Conservation (EGEE&C), which reports to APEC's Energy Working Group. One of the tasks of the EGEE&C is updating and maintaining the APEC Energy Standards Information System (ESIS). ESIS provides public, up-to-date information on appliance and equipment energy standards and regulations. It also provides links to experts and information related to standards and regulations used by APEC and other economies. NRCan contributes regularly to the database by providing updated information on Canadian equipment standards and labelling and new initiatives, such as the phase-out of incandescent lamps.

Asia-Pacific Partnership

The OEE participates through the Asia-Pacific Partnership (APP) on Clean Development and Climate on a task force on standby power data to internationally coordinate its efforts to reduce standby power consumption.

CanmetENERGY participates in the APP on three task forces: the Buildings and Appliances Task Force (BATF), the Renewable Energy and Distributed Power Generation Task Force (REDGTF) and the Cleaner Fossil Energy Task Force (CFETF). The Electricity Resources Branch of NRCan is the federal lead of the Power Generation and Distribution Task Force in 2010.

CanmetENERGY-Devon administered a project to develop corporate's guidelines for energy and emissions management at the China National Petroleum Corporation's upstream oil and natural gas facilities. This work was in collaboration with the Environment Canada Climate Change International Branch, APP funding and the U.S. Environmental Protection Agency (EPA). Also, a joint workshop for the APP CFETF and the international Methane to Markets Partnership's Oil and Gas Subcommittee was co-hosted at Lake Louise, Alberta, by CanmetENERGY-Devon, Environment Canada and the EPA.

Within the BATF and REDGTF, CanmetENERGY proposed the Net Zero Energy Homes initiative. Under this initiative, Canadian delegates have initiated a collaborative dialogue with BATF

and REDGTF partners to establish a formal international partnership that will map the path to achieving net zero energy homes.

Through a series of workshops and design charettes, Canada offered APP member countries an opportunity to set a precedent for housing performance optimization by bringing together the fragmented supply chain to discuss issues facing the sector. Participation from the project leaders of the existing BATF and REDGTF projects has ensured synergies. The workshops prominently featured Canadian industries, case studies and research, development and demonstration, potentially leading to commercial and technology transfer opportunities for Canadian firms.

As of May 2010, the APP had endorsed 175 projects and 22 flagship projects. Flagship projects comprise a portfolio of projects and activities that collectively exemplify the vision and objectives of the APP. Canada is involved in 30 APP projects.

U.S.-Canada Clean Energy Dialogue

The U.S.-Canada Clean Energy Dialogue (CED) was launched by Prime Minister Harper and President Obama in February 2009. It is a strategy for aligning regulatory standards and enhancing collaboration on the development of clean energy technologies to reduce GHG emissions. There are three working groups under the CED, and NRCan is involved in two of them: the Electric Grid Working Group and the Clean Energy Research and Development Working Group. Both focus areas are detailed in the CED Action Plan, which was presented to the Prime Minister and President in September 2009.

The Electricity Grid Working Group is focused on bilateral co-operation facilitating the long-term transition to a modernized electricity system based on clean and renewable generation. This facilitation includes identifying options for increasing Canada-U.S. trade in clean electricity, including the role that energy storage technologies might play in accommodating increased penetration of renewable sources. The facilitation also includes sharing best practices and engaging provinces, territories, industry and stakeholders in increasing the application of communications technologies, sensors and computer software to the electrical system – a concept known as the smart grid.

Human resources challenges are a particular problem in the electricity sector because of significant infrastructure renewal and modernization requirements. To foster dialogue on workforce issues, the Working Group brought together leading experts from industry and academia to identify required skills and share best practices. An outcomes report and recommendations were issued in summer 2010.

Energy storage technologies may hold the key for accommodating high proportions of intermittent renewable energy sources on the electric grid. However, these technologies face several technological, economic and regulatory barriers. To further understanding of these barriers, the Working Group commissioned a scoping paper that was presented in conjunction with a CED conference focused on increasing Canada-U.S. trade in clean electricity in May 2010.

R&D drives technological discovery and innovation, which are key ingredients in developing the low-carbon energy system of the future. The Clean Energy R&D working group aims to facilitate greater cross-border R&D collaboration by connecting Canadian and U.S. experts and institutions in priority areas for the Clean Energy Dialogue, including future-generation biofuels, clean engines/vehicles, and energy efficiency (homes and buildings). Strengthening collaboration in these areas through joint research, development and deployment will help reduce GHG emissions while strengthening both countries' economies and creating new jobs.

The ENERGY STAR program is an on-going collaborative activity under the Clean Energy R&D Working Group. Expanding collaboration in the program will increase the availability and

number of energy-efficient products and appliances and facilitate the harmonization of the North American equipment market.

NRCan's Buildings Division is working with the EPA to develop a Canadian version of the U.S. ENERGY STAR building benchmarking program. The "Measure it, Manage it" Building Energy Benchmarking System tool will allow benchmarking of energy use of building types in both countries. This tool will help building operators and owners and energy utilities track, benchmark and manage energy consumption to reduce GHG emissions from commercial and institutional buildings.

United States

In addition to collaboration through the Clean Energy Dialogue, NRCan's OEE signed an MOU with the EPA in September 2005 to share in the common goal of achieving greater energy efficiency and reducing CO_2, particulate matter and oxides of nitrogen emissions through the work of their respective programs: ecoENERGY for Fleets (FleetSmart) and the SmartWay Transport Partnership.

These two programs use a voluntary approach with the on-road freight sector to increase energy efficiency through training, education and the reporting of initiatives. They are working together to harmonize program efforts in Canada and the United States.

In 2009, CanmetENERGY, working with the Standards Council of Canada, formed a National Smart Grid Technology and Standards Task Force to provide Canadian input into smart grid standardization activities being led by the U.S. National Institute of Standards and Technology. This process is engaging key stakeholders and regulators in Canada and has enhanced Canada-U.S. collaboration on smart grid interoperability issues.

North America

CanmetENERGY has established partnerships among Canada, the United States and Mexico under the Security and Prosperity Partnership (SPP) of North America to support marine energy research and low-head hydropower demonstrations. CanmetENERGY and other Canadian partners in the SPP program are collaborating with the United States to optimize the rotor design, electricity production and interconnection for the next generation of Verdant Power's *Free Flow* Kinetic Hydropower System, for use in tidal currents and in-stream river applications. Through the same program, CanmetENERGY has created collaborative support for the demonstration of an innovative very low-head hydropower technology in Canada to evaluate the impacts on fish behaviour and the adaptation of the technology for cold climates.

NRCan also continues to work with the United States and Mexico through the Energy Efficiency Experts Group (EEEG) to promote the SPP agenda of harmonizing energy efficiency standards and co-operating on energy efficiency labelling programs. The EEEG is one of nine expert groups of the North American Energy Working Group.

APPENDIX 1

NRCan's Efficiency and Alternative Energy Initiatives and Expenditures, 2009-2010

	(millions of dollars)
Energy Efficiency and Alternative Transportation Fuels[1]	**$530.4**
ecoENERGY for Equipment	
ecoENERGY Retrofit – Homes	
ecoENERGY Retrofit – Small and Medium Organizations	
Federal Buildings Initiative	
ecoENERGY for Buildings and Houses	
ecoENERGY for Industry	
ecoENERGY for Personal Vehicles	
ecoENERGY for Fleets	
ecoENERGY for Biofuels	
National Renewable Diesel Demonstration	
National Energy Use Database	

[1] The Energy Efficiency and Alternative Transportation Fuels total does not include the Sustainable Development Technology Canada – NextGen Biofuels Fund™. For details on this fund, refer to the text box on page 66.

	(millions of dollars)
Energy Efficiency – Energy Science and Technology[2]	**$81.9**
Clean Energy Systems for Buildings and Communities	
Clean Electric Power Generation	
Clean Energy Systems for Industry	
Environmentally Sustainable Oil and Gas	
Clean Transportation Energy	
Sustainable Bioenegy	
Canadian Biomass Innovation Network	
Alternative Energy – Renewable Energy Sources	**$148.3**
ecoENERGY for Renewable Heat	
ecoENERGY for Renewable Power	
Pulp and Paper Green Transformation Program	
Wind Power Production Incentive[3]	
Initiative to Purchase Electricity From Emerging Renewable Energy Sources[4]	
Total	**$760.6**

[2] Totals allocated for the Program of Energy Research and Development, ecoENERGY Technology Initiative, and the Clean Energy Fund in Chapter 4 are reflected in the relevant program entries.

[3] The Wind Power Production Incentive is fully committed, but incentives will be paid out to recipients until 2016–2017.

[4] The Initiative to Purchase Electricity From Emerging Renewable Sources is fully committed, but incentives will be paid out until 2011–2012.

APPENDIX 2

Data Presented in the Report

The aggregate energy use data presented in this report are taken from Statistics Canada's *Report on Energy Supply and Demand in Canada* (RESD). Some adjustments to the original Statistics Canada data were required and are documented in Appendix A of NRCan's *Energy Use Data Handbook, 1990 to 2007.* The differences that exist between this report and *Canada's Energy Outlook* relate to the sector allocations of RESD energy-use data.

FIGURE 1-1: Secondary Energy Use by Sector, 2007

Sector	Industrial	Transportation	Residential	Commercial/ Institutional	Agriculture	Total
Energy use (PJ)	3 471.60	2 595.20	1 447.20	1 141.60	215.00	8 870.50
Percentage	39.1	29.3	16.3	12.9	2.4	100.0

FIGURE 1-2: GHG Emissions From Secondary Energy Use by Sector, 2007

Sector	Transportation	Industrial	Residential	Commerical/ Institutional	Agriculture	Total
GHG emissions (Mt)	179.4	168.5	74.3	64.5	14.9	501.6
Percentage	36.0	34.0	15.0	13.0	3.0	100.0

FIGURE 1-3: Energy Intensity and the Energy Efficiency Effect, 1990 to 2007

Index (1990 = 1.00)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Energy intensity index	1.00	1.00	1.00	1.00	0.99	0.98	1.00	0.96	0.91	0.89	0.88	0.84	0.85	0.86	0.85	0.82	0.77	0.81
Index of energy efficiency effect	1.00	0.98	0.97	0.96	0.96	0.92	0.93	0.91	0.89	0.87	0.87	0.85	0.85	0.86	0.85	0.81	0.80	0.84

FIGURE 1-4: Secondary Energy Use, Actual and Without Energy Efficiency Improvements, 1990 to 2007

Index (1990 = 1.00)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Estimated secondary energy use without energy efficiency improvements	1.00	1.00	1.03	1.05	1.10	1.15	1.18	1.20	1.20	1.25	1.29	1.28	1.32	1.35	1.38	1.40	1.39	1.44
Actual energy use	1.00	0.98	1.00	1.02	1.05	1.07	1.11	1.11	1.09	1.13	1.17	1.14	1.18	1.22	1.24	1.23	1.19	1.28

FIGURE 1-5: Canadian Households by Type of Dwelling, 2007

Dwelling type	Number of households (thousands)	Percentage
Single detached homes	7 322	56
Single attached homes	1 375	11
Apartments	4 039	31
Mobile homes	249	2
Total	**12 985**	**100**

FIGURE 1-6: Residential Energy Use by End Use, 2007

Activity	Energy use (PJ)	Percentage
Space heating	908.1	63
Water heating	257.9	18
Appliances	192.4	13
Lighting	60.8	4
Space cooling	27.9	2
Total	**1447.2**	**100**

FIGURE 1-7: Number of Households, Average Floor Space by Household and Energy Intensity Indexes, 1990 to 2007

Index (1990 = 1.00)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Number of households	1.00	1.03	1.05	1.07	1.08	1.10	1.12	1.13	1.14	1.16	1.18	1.20	1.21	1.23	1.25	1.27	1.29	1.31
Average floor space by household	1.00	1.00	1.01	1.01	1.02	1.02	1.03	1.03	1.03	1.03	1.03	1.02	1.02	1.03	1.04	1.06	1.08	1.09
Energy intensity (GJ)/ household)	1.00	0.96	0.97	0.98	0.98	0.95	1.01	0.96	0.86	0.89	0.92	0.87	0.89	0.91	0.88	0.86	0.81	0.86

FIGURE 1-8: Residential Energy Use, Actual and Without Energy Efficiency Improvements, 1990 to 2007

Index (1990 = 1.00)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Estimated energy use without energy efficiency improvements	1.00	1.04	1.10	1.14	1.14	1.17	1.22	1.21	1.13	1.17	1.24	1.21	1.28	1.31	1.33	1.36	1.33	1.42
Actual energy use	1.00	0.98	1.01	1.04	1.07	1.05	1.13	1.08	0.99	1.03	1.08	1.04	1.08	1.12	1.10	1.09	1.04	1.13

FIGURE 1-9: Annual Heating* Consumption for Houses Constructed to Different Standards

House type	ecoENERGY Retrofit Homes annual heating* consumption (GJ)	Sample size	Total consumption (GJ)
Typical existing house** (1970)	146	8661	177.9
Model National Energy Code house*** (2002)	112	1	143.34
Average** of EnerGuide labelled houses (2007)	89	3992	120.68
Average** of R-2000 certified houses	76	520	107.05

* DHW and space heating
** National average
*** 198-m², two-storey, single detached house heated with natural gas located in Ottawa, Ontario

FIGURE 1-10: Average Energy Consumption of New Electric Appliances, 1990 and 2007 Models

Appliance	1990 model (kWh/yr)	2007 model (kWh/yr)
Clothes washers	97	23
Clothes dryers	1103	912
Dishwashers	227	57
Refrigerators	956	483
Electric ranges	772	524
Freezers	714	384

FIGURE 1-11: Commercial/ Institutional Energy Use by Activity Type,* 2007

Activity types	Energy use (PJ)	Percent
Offices**	397.37	35
Retail trade	191.14	17
Educational services	153.91	14
Health care and social assistance	111.21	10
Accommodation and food services	87.7	8
Wholesale trade	66.08	6
Transportation and warehousing	45.1	4
Arts, entertainment and recreation	34.88	3
Information and cultural industries	25.91	2
Other services	19.85	2
Total	**1133.15**	**100**

* Excludes street lighting.
** "Offices" includes activities related to finance and insurance; real estate and rental and leasing; professional, scientific and technical services; and public administration.

FIGURE 1-12: Commercial/Institutional Energy Use by Purpose, 2007

Purpose	Energy use (PJ)	Percent
Space heating	572.5	50
Auxiliary equipment	189.7	17
Lighting	110.3	10
Water heating	94.7	8
Auxiliary motors	90.4	8
Space cooling	75.5	7
Street lighting	8.4	1
Total	**1141.5**	**100**

FIGURE 1-13: Commercial/Institutional Energy Use, Actual and Without Energy Efficiency Improvements, 1990 to 2007

Index (1990 = 1.00)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Estimated energy use without energy efficiency improvements	1.00	1.05	1.08	1.13	1.14	1.16	1.20	1.20	1.17	1.22	1.26	1.27	1.34	1.36	1.37	1.43	1.40	1.48
Actual energy use	1.00	1.03	1.04	1.08	1.07	1.11	1.13	1.15	1.09	1.13	1.24	1.22	1.31	1.35	1.35	1.34	1.26	1.32

FIGURE 1-14: Industrial Energy Use by Subsector – Including Electricity-Related Emissions,* 2007

Subsector	Energy Use (PJ)	Industrial Energy Use (%)
Mining	867.0	25.0
Other manufacturing**	721.0	20.8
Pulp and paper	668.7	19.3
Petroleum refining	362.4	10.4
Smelting and refining	271.6	7.8
Iron and steel	224.0	6.5
Chemicals	204.8	5.9
Cement	69.7	2.0
Construction	62.4	1.8
Forestry	19.6	0.6
Total	**3471.6**	**100.0**

* The above subsectors reflect the current definitions in the *Report on Energy Supply and Demand in Canada.*
** "Other manufacturing" comprises more than 20 manufacturing industries.

FIGURE 1-15: Cost of Energy to Manufacturing Industries as a Percentage of Total Production Cost, 2007

Industry	Energy cost of total production cost (%)
Transportation equipment and manufacturing	0.7
Petroleum refining	1.5
Chemicals	5.0
Iron and steel	11.4
Pulp and paper	10.5
Aluminum	9.9
Cement	22.9

FIGURE 1-16: Industrial Energy Use, Actual nd without Energy Efficiency Improvement, 1990 to 2007

Index (1990 = 1.00)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Estimated energy use without energy efficiency improvements	1.00	1.00	1.02	1.04	1.10	1.14	1.15	1.17	1.20	1.25	1.29	1.27	1.32	1.33	1.35	1.36	1.32	1.35
Actual energy use	1.00	0.99	0.99	1.00	1.05	1.08	1.10	1.10	1.09	1.12	1.15	1.11	1.17	1.20	1.22	1.20	1.16	1.28

FIGURE 1-17: Industrial Energy Use, With and Without Energy Efficiency Improvements (Without Upstream Mining), 1990 to 2007

Index (1990=1.00)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Estimated energy use without energy efficiency improvements	1.00	1.01	1.02	1.01	1.09	1.12	1.13	1.15	1.17	1.23	1.28	1.26	1.31	1.32	1.34	1.34	1.30	1.33
Actual energy use	1.00	0.99	0.98	0.96	1.02	1.04	1.05	1.05	1.04	1.06	1.09	1.04	1.09	1.09	1.12	1.07	1.02	1.09

FIGURE 1-18: Transportation Energy Use by Mode, 2007

	Energy use (PJ)	Percentage
Car	664.7	
Passenger light trucks	438.1	
Motocycles	4.0	
School buses	12.4	
Urban transit	30.3	
Inter-city buses	6.4	
Passenger air	253.9	
Passenger rail	2.6	
Passenger total	**1412.4**	**54.4**
Freight light trucks	176.2	
Medium trucks	156.2	
Heavy trucks	548.4	
Freight air	5.8	
Freight rail	83.9	
Marine	109.0	
Freight total	**1079.5**	**41.6**
Off-road total	**102.1**	**3.9**
Total transportation energy use	**2594.0**	**100.0**

FIGURE 1-19: Market Shares of New Passenger Car and Light-Truck Sales, 1990 to 2007 (percentage)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Passenger car	74.7	75.2	72.7	69.7	67.2	65.0	62.8	59.7	59.1	60.9	63.0	63.4	62.7	62.1	61.6	61.6	61.1	59.5
Passenger light truck	25.3	24.8	27.3	30.3	32.8	35.0	37.2	40.3	40.9	39.1	37.0	36.6	37.3	37.9	38.4	38.4	38.9	40.5

FIGURE 1-20: Transportation Energy Use, Actual and Without Energy Efficiency Improvements, 1990 to 2007

Index (1990=1.00)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Estimated energy use without energy efficiency improvements	1.00	0.98	1.01	1.05	1.12	1.15	1.18	1.23	1.27	1.32	1.34	1.36	1.38	1.41	1.51	1.53	1.55	1.59
Actual energy use	1.00	0.96	0.99	1.00	1.05	1.07	1.09	1.13	1.17	1.20	1.22	1.21	1.23	1.26	1.31	1.33	1.33	1.38

FIGURE 1-21: Average Activity per Truck, 1990 to 2007 (tonne kilometres/truck)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Total medium- and heavy-duty truck vehicle activity	105 779	98 642	103 508	117 665	133 777	142 851	141 271	164 079	162 940	175 178	178 398	198 907	197 518	202 313	241 247	243 756	238 925	236 663

FIGURE 1-22: Trucking Energy Intensity, 1990 to 2007 (megajoules/tonne kilometre)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Total medium-and heavy-duty trucks energy intensity	3.74	3.81	3.81	3.64	3.44	3.50	3.42	3.33	3.18	3.02	3.05	2.85	2.82	2.93	2.62	2.65	2.71	2.81

FIGURE 2-1: Volume of Monthly Import Documents

Month	Paper	Electronic	Total
Apr. 09	17	103 991	104 008
May 09	30	112 666	112 696
Jun. 09	46	121 992	122 038
July 09	99	126 970	127 069
Aug. 09	1	128 215	128 216
Sept. 09	218	129 675	129 893
Oct. 09	146	140 222	140 368
Nov. 09	32	124 412	124 444
Dec. 09	..	124 766	124 766
Jan. 10	11	117 320	117 331
Feb. 10	88	122 166	122 254
Mar. 10	71	140 060	140 131
Total	**759**	**1 492 455**	**1 493 214**

FIGURE 2-4 Distribution of ENERGY STAR® Qualified Shipments of Appliances, 1999–2008

Appliance	1999 (%)	2000 (%)	2001 (%)	2002 (%)	2003 (%)	2004 (%)	2005 (%)	2006 (%)	2007 (%)	2008 (%)
Dishwashers	0.6	1.6	9.7	29.8	56.5	81.0	90.8	79.7	76.2	89.3
Clothes washers	1.9	2.2	9.2	22.1	30.6	36.2	45.9	50.8	58.4	64.4
Refrigerators	..	..	11.4	22.3	40.7	34.2	37.6	37.3	44.3	53.4

FIGURE 2-5: ENERGY STAR® Awareness Levels in Canada, 2010

	Percentage
Aware – non-aided	71
Aware – aided	72

FIGURE 3-1: Residential Energy Use and Energy Savings per Household, Pre-1945 to 2000–2009

	Pre-1945	1945-1959	1960-1969	1970-1979	1980-1989	1990-1999	2000-2009*	Average
Energy use pre-renovation (GJ)	271	200	187	174	174	163	149	193
Actual energy savings after renovations (GJ)	85	52	44	40	35	29	31	47

* Data for 2007 are from ecoENERGY Retrofit – Homes (previous data source was EnerGuide for Houses).

FIGURE 3-2: Number of R-2000 Housing Certifications, 1990 to 2009

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Number of R-2000 certifications	495	699	1196	1299	784	610	416	484	265	213	319	329	428	379	583	500	439	483	557	484

FIGURE 3-3: New Vehicle Fuel Efficiency Labelling

Year	On lot (%)	In showroom (%)
2007	78	56
2005	78	61
2001	77	56
1999	64	47

FIGURE 3-4: Company Average Fuel Consumption (CAFC) versus Canadian Voluntary Standards, 1990 to 2009*

Model year	Truck standard (L/100 km)	Trucks CAFC (L/100 km)	Car standard (L/100 km)	Cars CAFC (L/100 km)
1990	11.8	11.3	8.6	8.2
1991	11.6	11.4	8.6	8.0
1992	11.6	11.1	8.6	8.1
1993	11.5	11.3	8.6	8.1
1994	11.5	11.1	8.6	8.2
1995	11.4	11.5	8.6	7.9
1996	11.4	11.5	8.6	7.9
1997	11.4	11.3	8.6	8.0
1998	11.4	11.4	8.6	7.9
1999	11.4	11.3	8.6	7.9
2000	11.4	11.1	8.6	7.8
2001	11.4	11.0	8.6	7.8
2002	11.4	11.0	8.6	7.7
2003	11.4	10.8	8.6	7.6
2004	11.4	10.7	8.6	7.5
2005	11.2	10.5	8.6	7.4
2006	10.9	10.4	8.6	7.5
2007	10.6	10.1	8.6	7.2
2008	10.5	9.5	8.6	7.1
2009	10.2	9.1	8.6	6.8

* 2009 data are estimates.

FIGURE 4-1: RETScreen Software: Cumulative Growth of User Base

	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Canada	1 421	2 966	4 527	6 650	9 754	14 125	18 178	24 005	28 990	36 891	44 987	54 152
World	1 688	5 782	9 838	15 292	20 499	27 752	38 270	56 432	78 215	110 264	148 046	188 623

FIGURE 5-1: Canadian Wind Power Capacity, 1993 to 2009

	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Wind power capacity (MW)	1	22	23	23	24	27	127	139	215	233	326	445	686	1459	1846	2369	3319

Natural Resources Canada's Office of Energy Efficiency

Leading Canadians to Energy Efficiency at Home, at Work and on the Road

Canada

...sources Ressources naturelles
Canada

Improving Energy Performance in Canada

Report to Parliament Under the *Energy Efficiency Act*
For the Fiscal Year 2010-2011

Canada

The digital mosaic of Canada that appears on the cover of this publication is produced by Natural Resources Canada (Canada Centre for Remote Sensing) and is a composite of individual satellite images. The differences in the density of vegetation are illustrated through shading.

Publishing by the authority of the Minister of Natural Resources Canada
Government of Canada

Aussi disponible en français sous le titre : Améliorer le rendement énergétique au Canada – Rapport au Parlement en vertu de la *Loi sur l'efficacité énergétique* pour l'année financière 2010–2011

Cat. No. M141-10/2011E (Print)
ISSN 1491-0624

Cat. No. M141-10/2011E-PDF (On-line)
ISSN 1719-3478

To obtain additional copies of this or other free publications on energy efficiency, please contact:

Energy Publications
Office of Energy Efficiency
Natural Resources Canada
c/o St. Joseph Communications
Order Processing Unit
1165 Kenaston Street
PO Box 9809 Station T
Ottawa ON K1G 6S1
Tel.: 1-800-387-2000 (toll-free)
Fax: 613-740-3114
TTY: 613-996-4397 (teletype for the hearing-impaired)

You can also view or order most Office of Energy Efficiency publications on-line.
Visit our Virtual Library at oee.nrcan.gc.ca/publications. The Office of Energy Efficiency's Web site is at oee.nrcan.gc.ca.

Table of Contents

List of Figures and Tables

Figures

Tables

Minister's Foreword

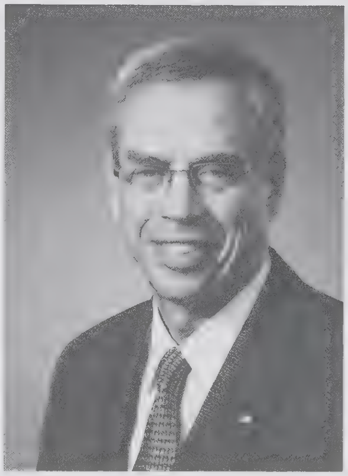
I am pleased to introduce the *2010–2011 Report to Parliament on Improving Energy Performance in Canada*. Canada has one of the world's largest resource endowments of both traditional and emerging sources of energy. It is increasingly looked to as a secure and dependable supplier of a wide range of energy products.

Our Government is committed to taking concrete action to reduce greenhouse gas emissions and help protect the environment by investing in clean energy technologies that demonstrate the greatest potential for progress.

Building on initiatives started in 2006, the Next Phase of Canada's Economic Action Plan renewed support for energy efficiency activities. The $195-million ecoENERGY Efficiency Program is helping to improve energy efficiency, reduce greenhouse gas emissions, improve air quality and save money for Canadians and Canadian businesses.

In Budget 2011, we also renewed the popular ecoENERGY Retrofit – Homes program to enable as many as 250,000 more Canadians to increase the energy efficiency of their homes. Participants, on average, reduced their annual energy consumption by about 21 percent and greenhouse gas emissions by approximately three tonnes per household per year.

On the international stage, we are continuing to work with the United States, through the Clean Energy Dialogue, to enhance joint collaboration on the development of clean energy science and technologies to reduce greenhouse gases and combat climate change.



© Couvrette/Ottawa

This fall, we signed an agreement with the U.S. Environmental Protection Agency to create a common platform for measuring and assessing the energy performance of commercial buildings in both countries.

We will also continue to implement measures to sharpen Canada's competitiveness, productivity and capacity for innovation using clean energy technologies including renewables, carbon capture and storage, and the use of forest and agricultural by-products to generate energy. Our investments not only create innovation and jobs — they also build a better economy.

We all have an important role to play in building a clean energy future for Canadians.

The Honourable Joe Oliver, P.C., M.P.
Minister of Natural Resources

Executive Summary

Canadians spent approximately $189 billion in 2008 on energy to heat and cool their homes and offices and to operate their appliances, cars and industrial processes. Several factors contribute to Canadian energy demand: a vast geography, a northern climate with extreme seasonal variations in temperature and an economy founded on an abundance of natural resources.

Types of Energy Use

The two general types of energy use are primary and secondary. Primary use represents Canada's total consumption, including energy required to transform one energy form to another – such as coal to electricity – and energy required to deliver energy to consumers. Secondary use is energy consumed for residential, commercial/institutional, industrial, transportation and agricultural purposes.

Key highlights in energy use include the following:

- Between 1990 and 2008, the latest year for which figures are available, secondary energy use increased by 26 percent.
- In 2008, secondary use accounted for 70 percent of primary energy use and produced 66 percent (487.8 megatonnes [Mt]) of Canada's total greenhouse gas (GHG) emissions. This last figure includes emissions produced by utilities in meeting the demand for electricity.
- Energy efficiency has improved 18 percent since 1990. These improvements reduced energy use by approximately 1 205.9 petajoules, decreased GHG emissions by 67.3 Mt and saved Canadians $26.9 billion in 2008.

The industrial sector consumed the most energy, accounting for 37 percent of total secondary energy use in 2008. Transportation was second (30 percent), followed by residential (17 percent), commercial/institutional (14 percent) and agriculture (2 percent).

Promoting Energy Efficiency

Natural Resources Canada (NRCan) promotes energy efficiency and the use of alternative energy as a means to reduce GHG emissions and save money. NRCan uses a broad range of policy instruments, including leadership; information; voluntary initiatives; financial incentives; research, development and demonstration; and regulation.

The *Energy Efficiency Act*, which came into force in 1992, provides for the making and enforcement of regulations concerning minimum energy performance levels for energy-using products, the labelling of energy-using products and the collection of data on energy use. The *Energy Efficiency Regulations* are described in Chapter 2.

Energy Intensity / Energy Efficiency

As explained in Chapter 1, although energy intensity is sometimes used as a proxy for energy efficiency, there is a difference between the terms. It is important to understand this difference when comparing Canada with other countries.

Energy efficiency refers to how effectively energy is being used for a given purpose. For example, providing a similar (or better) level of service with

less energy consumption on a per-unit basis is considered an improvement in energy efficiency.

Energy intensity is the amount of energy use per unit of activity. Examples of activity measures in this report are households, floor space, passenger-kilometres, tonne-kilometres, physical units of production and constant dollar value of gross domestic product. Energy intensity is a broader measure, capturing not only energy efficiency but also other impacts on energy consumption, such as weather variations, market behaviour and changes in the structure of the economy.

Evidence of Change

As explained in this report, recent growth in energy use is primarily due to increased activity in various sectors. However, this growth would have been much greater without improvements in energy efficiency.

As reported in Chapter 1, energy efficiency improvements made between 1990 and 2008 are estimated to have reduced GHG emissions by 67.3 Mt and saved Canadians $26.9 billion in 2008.

Between 1990 and 2008, the residential sector recorded a 31 percent improvement in energy efficiency. The figures for the transportation (21 percent), industrial (12 percent) and commercial/institutional (12 percent) sectors demonstrate that improvements in energy efficiency are being made throughout the economy.

Through improvements in energy efficiency, Canadians can reduce their energy bills and achieve important environmental goals. Over the short term, changing to less GHG-intensive fuels (e.g. from coal to natural gas) can help reduce GHG emissions. However, over the long term, reducing GHG emissions further will require more widespread use of alternative energy.

Canada is a world leader in the production of renewable energy, with almost 16.9 percent of its primary energy supply coming from renewable energy sources in 2009.

Engaging Canadians

To maximize the effectiveness of its initiatives, NRCan engages a growing number of partners from the private and public sectors. Dozens of co-operative agreements are in place with a broad range of businesses, community groups and other levels of government.

These initiatives engage Canadian society, along with every sector of the economy, in new and more efficient approaches to secondary energy use and in the development and deployment of renewable energy sources.

This report provides an overview of the work being done in each sector and highlights NRCan's efficiency and alternative energy programs and lists their key achievements for the 2010–2011 fiscal year. Program entries for market transformation programs also include quantitative performance indicators in graph or table format. A list of NRCan's efficiency and alternative energy initiatives and expenditures appears in Appendix 1.

Introduction

NATURAL RESOURCES CANADA'S EFFICIENCY AND ALTERNATIVE ENERGY PROGRAMS

According to the International Energy Agency, if energy efficiency policies had not been introduced 30 years ago, today's worldwide energy consumption would be 50 percent higher.[1]

Gains in energy efficiency have substantial benefits for society, the economy and the environment. Energy efficiency can add to the global security of energy supplies by reducing the need for energy. It saves consumers and businesses money by decreasing their energy bills without disruptions to their daily routine, and it can increase access to energy services by reducing their effective cost. Energy efficiency also positively impacts economic competitiveness and employment.

In particular, greater energy efficiency is used as a strategy to reduce carbon dioxide and other greenhouse gases (GHGs) and thereby help reduce the effects of climate change.

Natural Resources Canada (NRCan) emphasizes the promotion of energy efficiency and the use of alternative energy (i.e. alternative transportation fuels and renewable energy) as ways to reduce GHG emissions and improve the Canadian economy.

A complete list of NRCan's efficiency and alternative energy (EAE) initiatives in 2010–2011 is in Appendix 1.

These initiatives engage Canadian society and all major sectors of the economy in new and more advanced approaches to secondary energy use – i.e. to the consumption of energy in the residential, commercial/institutional, industrial and transportation sectors.

NRCan's EAE initiatives are managed by the following:

- the Office of Energy Efficiency, which delivers market transformation initiatives to improve energy efficiency and the use of alternative transportation fuels
- the CanmetENERGY Minerals and Metals Sector, which delivers EAE research, development and demonstration (R,D&D) initiatives
- the Office of Energy Research and Development, which coordinates NRCan's energy research and development (R&D) planning and fund allocations
- the Electricity Resources Branch, which delivers market transformation initiatives for renewable energy
- the Science Branch of the Canadian Forest Service, which undertakes R&D in the use of forest biomass for energy
- the Policy, Economics and Industry branch of the Canadian Forest Service, which delivers funding for environmental improvements in pulp and paper mills and the commercialization of innovative technologies across the forest sector

[1] International Energy Agency, *Mind the Gap: Quantifying Principal-Agent Problems in Energy Efficiency, 2007.*

In its efforts to improve energy efficiency and increase the use of alternative energy, NRCan emphasizes partnership and co-operation with stakeholders, such as other levels of government, the private sector and nongovernmental organizations.

With this approach, the demand side of the energy market moves toward more energy-efficient capital stock, production processes and operating practices without reducing service or comfort levels. On the supply side, Canada participates in developing technology for tapping renewable energy resources and alternative transportation fuels and in increasing the energy efficiency of energy production.

POLICY INSTRUMENTS

NRCan's key policy instruments are as follows:

- regulation
- financial incentives
- leadership
- information
- voluntary initiatives
- research, development and demonstration

Regulation

The *Energy Efficiency Act* gives the Government of Canada the authority to make and enforce regulations that prescribe standards and labelling requirements for energy-using products that are imported to Canada or shipped across provincial borders for lease or resale and to prescribe standards for products that affect energy use.

Financial Incentives

NRCan uses financial incentives to encourage end-users of energy to adopt energy efficiency and renewable energy technologies and practices. In 2010–2011, NRCan offered financial incentives for renewable power and heat, ethanol and biodiesel plants, energy efficiency and renewable energy production at pulp and paper mills, natural gas vehicles and refuelling infrastructure.

Leadership

Leadership means setting an example for other levels of government and for the private sector by increasing energy efficiency and the use of alternative energy in the Government of Canada's operations.

Information

NRCan disseminates information to consumers, using methods ranging from broad distribution to individual consultations with clients. This increases awareness of the environmental impact of energy use and encourages consumers to become more energy efficient and make greater use of alternative energy sources.

Information activities include publications, exhibits, advertising, toll-free telephone lines, conferences, Web sites, workshops, training, building-design software and promotional products. One particular outreach program targets youth as the energy consumers of the future and distributes activity booklets to virtually all elementary schools across the country.

Voluntary Initiatives

Companies and institutions work with NRCan voluntarily to set and achieve energy efficiency objectives. NRCan's voluntary EAE initiatives target the commercial/institutional and industrial sectors and organizations whose products are major factors in energy use. The initiatives involve industry-government agreements and, for groups of large industrial energy users, commitments to develop energy efficiency improvement targets and action plans. NRCan provides support to assist and stimulate action by companies and institutions on energy efficiency, including developing standards, educational material and training.

Research, Development and Demonstration

Ongoing improvement in energy efficiency is contingent on improvements and innovations in technology. NRCan's EAE initiatives support the

development and dissemination of more energy-efficient equipment, processes and technologies and alternative energy technologies. R,D&D also provides the scientific knowledge needed to develop the technologies, codes, standards and regulations required for the sustainable use of energy.

NRCan provides national leadership in energy science and technology (S&T) by undertaking research in its own laboratories and contracting research activities to other organizations. These initiatives are the only federal interdepartmental S&T investment funds that focus on the energy sector and its economic and environmental effects.

FIGURE INT-1

Moving the Market

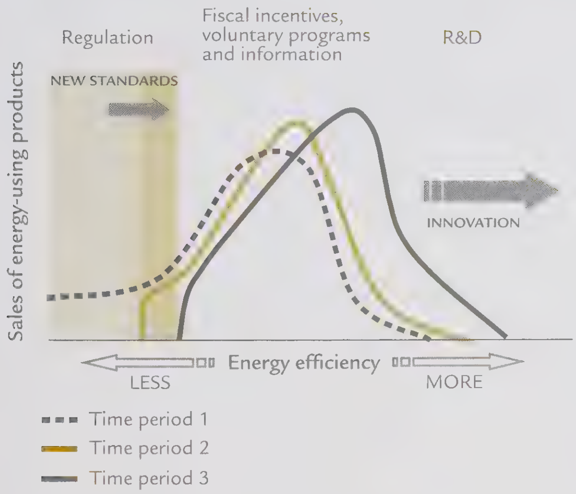


Figure Int-1 shows how these policy instruments work together to increase energy efficiency, that is, how they help to reduce the amount of energy required to complete a task or obtain a certain level of service. Energy performance regulations eliminate less efficient products from the market. Fiscal incentives, voluntary programs and information activities increase the number of people and organizations taking advantage of existing opportunities to use energy more efficiently.

R&D increases the opportunities for achieving higher levels of efficiency in a particular type of energy use.

MEASURING PROGRESS

The primary goal of NRCan's EAE initiatives is to change energy consumption patterns and thereby generate environmental and economic benefits. Part of assessing program progress and performance involves considering both program delivery and program effectiveness. NRCan monitors and tracks the following three aspects of program delivery:

- program outputs
- program outcomes
- market outcomes

Program outputs are the items produced regularly, such as information and marketing materials, demonstration projects, financial incentives and regulations. Program outputs are designed to lead to **program outcomes** – namely, changes in the behaviour of groups targeted by a program. These groups may be either energy users or producers of energy-using equipment or structures. For example, program outcomes occur when consumers purchase more energy-efficient appliances than they would have if there were no program. Other important factors that influence consumer behaviour include product price, household income, personal taste and government and non-government programs.

Because program outcomes can directly affect the amount and type of energy consumed in the market, they contribute, in part, to observable **market outcomes**. Market outcomes ultimately reflect the impacts of NRCan programs on changes in energy efficiency, energy intensity, GHG emissions and the use of alternative energy. In this sense, achievement of a targeted market outcome, or observable progress toward a market outcome, may serve as an indicator of program effectiveness. Measuring progress toward an immediate market outcome can be difficult for R,D&D programs, which typically take many years to produce results that can be properly assessed.

An example of a program outcome leading to a market outcome is a householder's purchase of a more energy-efficient appliance, resulting in reduced

use of electricity. Depending on what source of electricity is involved and how the utility changes its electricity-generating methods to meet the change in demand resulting from reduced electricity use, this could also lead to a decline in GHG emissions.

DATA COLLECTION AND ANALYSIS

In 1991, NRCan launched the National Energy Use Database (NEUD) initiative to help the Department improve its knowledge of energy consumption and energy efficiency at the end-use level in Canada and to support its analytical expertise. The NEUD initiative plays a number of crucial roles directly related to NRCan program activities. However, its most important role is to secure the development of a reliable, Canada-wide information base on energy consumption at the end-use level for all energy-consuming sectors.

The NEUD initiative consists of several broad components that typically involve conducting large- and small-scale surveys of energy use in the transportation, industrial, commercial/institutional and residential sectors. The surveys gather information about the stocks and characteristics of energy-using equipment and buildings, measuring Canadians' energy use and monitoring the adoption of new technologies in the marketplace.

In 2010–2011, an analysis of energy use inside and outside the dwelling was undertaken for reference year 2007. This analysis, which examines the penetration rates and energy use characteristics of indoor equipment, such as home electronics and fireplaces, and outdoor equipment, such as lawn mowers and snow blowers, is a complement to the Survey of Household Energy Use. Data on other sectors of the economy continue to be collected, analysed and published by the Office of Energy Efficiency.

The NEUD initiative also produces a comprehensive energy use database with accompanying publications to explain Canada's overall energy use and energy efficiency trends. All NEUD initiative reports are available to the public, free of charge, both in hard copy and online at oee.nrcan.gc.ca/statistics.

The NEUD initiative also contributes to the development of energy end-use data and analysis centres (DACs) across Canada. The DACs are mandated to improve the accessibility and comparability of existing data about trends in energy consumption and their impact on environmental quality, develop expert knowledge and advise on NEUD's data collection activities. Three DACs have been established:

- **transportation** at Université Laval in Québec, Quebec (Centre for Data and Analysis in Transportation [CDAT])
- **industrial** at Simon Fraser University in Burnaby, British Columbia (Canadian Industrial Energy End-Use Data and Analysis Centre [CIEEDAC])
- **buildings** at the University of Alberta in Edmonton, Alberta (Canadian Building Energy End-Use Data and Analysis Centre [CBEEDAC])

GHG EMISSIONS AND CLIMATE CHANGE

Climate change is a global challenge arising from the continuing buildup in levels of anthropogenic (human-produced) GHGs in the atmosphere in addition to naturally occurring emissions. GHGs are composed of several gases, and the main source of anthropogenic emissions is the combustion of fossil fuels. Substantially reducing GHG emissions is a challenge, particularly given Canada's highly industrialized and resource-based economy. Solutions require a multifaceted, coordinated domestic response and a high level of co-operation among all nations.

IN THIS REPORT

This eighteenth annual *Report to Parliament* focuses principally on EAE initiatives that address secondary energy use. Trends in energy use and GHG emissions in Canada for the residential, commercial/institutional, industrial, transportation and renewable energy sectors are discussed in Chapter 1.

Chapter 2 discusses equipment regulations under the *Energy Efficiency Act* and equipment-labelling activities. Chapter 3 describes the suite of ecoENERGY and related programs and lists key 2010–2011 achievements. Chapter 4 explains clean energy S&T programs and achievements related to energy efficiency and the continued integration of renewable sources. Chapter 5 outlines NRCan's involvement with renewable energy sources and use. The sixth and final chapter describes domestic and international co-operation in EAE.

Appendix 1 contains information about NRCan's EAE expenditures. Appendix 2 contains detailed information about the figure data presented in this report. Calculations of the estimated GHG savings in this report are based on Environment Canada's standardized emissions factors as described in its publication *Canada's Greenhouse Gas Inventory*. The emissions factor for electricity was based on the provincially weighted average of marginal fuel sources across the country.

CHAPTER 1 Trends in Energy Use

INTRODUCTION

Canadians enjoy an abundance of energy from a variety of sources. This comparative advantage in the supply of energy helps Canadians deal with the economic disadvantages of small domestic markets, long distances, rugged geography and a relatively harsh climate. It also fosters the development of industries with a particularly strong energy demand.

Canadians spent about $189 billion in 2008 on energy to heat and cool their homes and offices and to operate their appliances, vehicles and industrial processes. This amount is equivalent to almost 13 percent of the country's gross domestic product (GDP).[2]

ENERGY USE AND GREENHOUSE GAS EMISSIONS

Energy use is of two general types: primary and secondary. Primary energy use encompasses the total requirements for all users of energy, the energy required to transform one energy form to another (e.g. coal to electricity) and the energy used to bring energy supplies to the consumer. Secondary energy use is energy used by final consumers for residential, commercial/institutional, industrial, transportation and agricultural purposes.

Primary energy use represents the total requirements for all users of energy, including secondary energy use. In Canada, the increase in primary energy use reflects changes over several decades in energy-consuming equipment and buildings and in the behaviour of energy users. In 2008, the amount of primary energy consumed was estimated at 12 510.5 petajoules[3] (PJ).

DID YOU KNOW?

One petajoule is approximately equal to the energy used by almost 9 000 households in one year (excluding transportation use).

Secondary energy use accounted for almost 70 percent of primary energy use in 2008, or 8 720.2 PJ. It was responsible for 66 percent (487.8 megatonnes [Mt]) of total greenhouse gas (GHG) emissions in Canada, including indirect emissions – those produced by electric utilities to meet end-use electrical demand.

From 1990 to 2008, secondary energy use increased by 26 percent, the Canadian population grew 20 percent, and the GDP increased 62 percent. Thus energy use grew less rapidly than the economy but more rapidly than the population.

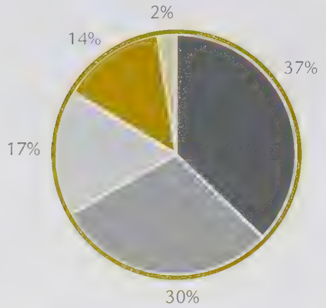
As demonstrated in Figure 1-1, the industrial sector was the largest energy user, accounting for 37 percent of total secondary energy use in 2008. The transportation sector was the second largest energy user at 30 percent, followed by the residential sector at 17 percent, the commercial/institutional sector at 14 percent and the agricultural sector at 2 percent.

[2] Data in this chapter are presented for 1990–2008. Readers are encouraged to consult the Office of Energy Efficiency Web site to view data updates as they become available.

[3] One petajoule equals 1×10^{15} joules.

FIGURE 1-1

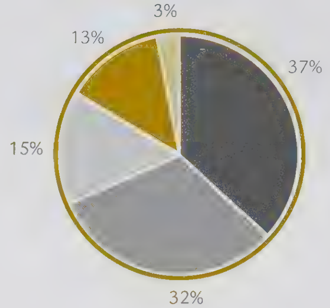
Secondary Energy Use by Sector, 2008



Source: oee.nrcan.gc.ca/corporate/statistics/neud/dpa/handbook_tables.cfm?attr=0

FIGURE 1-2

GHG Emissions From Secondary Energy Use by Sector, 2008



Source: oee.nrcan.gc.ca/corporate/statistics/neud/dpa/handbook_tables.cfm?attr=0

Figure 1-2 illustrates the distribution of GHG emissions by sector. This report deals with energy-related GHG emissions, which comprise carbon dioxide (CO_2), methane and nitrous oxide. CO_2 accounts for most of Canada's GHG emissions. All subsequent references in this report to CO_2 and GHGs include emissions that are attributable directly to secondary energy use and emissions that are attributable indirectly to electricity generation, unless otherwise specified.

ENERGY INTENSITY AND ENERGY EFFICIENCY

The term "energy intensity" refers to the amount of energy use per unit of activity. Energy intensity is sometimes used as a proxy for energy efficiency because it is a simple calculation for which data are readily available. However, this measure can be misleading because, in addition to pure energy efficiency, intensity captures the impact of other factors that influence energy demand, such as weather variations and changes in the structure of the economy.

Energy efficiency refers to how effectively energy is being used for a given purpose. For example, providing a similar (or better) level of service with less energy consumption on a per-unit basis is considered an improvement in energy efficiency.

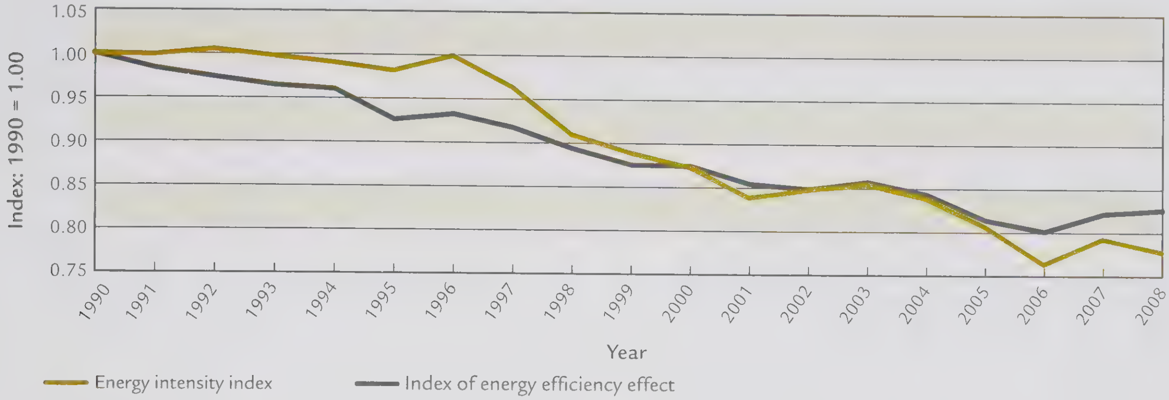
To properly gauge changes in energy efficiency over time, differences in economic structure and weather need to be normalized or factored out of the intensity calculation. Natural Resources Canada's (NRCan's) Office of Energy Efficiency (OEE) applies an internationally recognized factorization analysis technique – the Log-Mean Divisia Index I methodology – to isolate the impact of energy efficiency on changes in Canadian energy use.

Figure 1-3 compares, for Canada, an index of annual variation in energy intensity with the OEE's index of changes in energy efficiency from 1990 to 2008. As illustrated, Canada's energy intensity and efficiency improved over this period. The reduction in energy intensity reflects an overall improvement in energy efficiency or how effectively energy is being used in producing one unit of GDP. At the same time, the improvement in energy efficiency indicates how effectively energy is being used to provide a certain level of service or output.

As illustrated in Figure 1-3, intensity underestimates the efficiency effect in Canada in the early 1990s and overestimates its impact in the latter part of the period. Before 1998, intensity improvements appear to be modest because colder weather (1992–1997) and a shift toward more energy-intensive industries (1990–1996) masked energy efficiency progress. In 2000, the intensity index dipped below the index for

FIGURE 1-3

Energy Intensity and the Energy Efficiency Effect, 1990 to 2008



Source: Natural Resources Canada, Residential, Commercial/Institutional, Transportation, Industrial End-Use Models, Ottawa, 2010.

the energy efficiency effect. A switch to less energy-intensive industries, which began in the mid-1990s, combined with energy efficiency improvements accelerated the decline in energy intensity.

TRENDS IN ENERGY EFFICIENCY

NRCan regularly publishes *Energy Efficiency Trends in Canada*, which reports on changes in energy use and GHG emissions and the contributions of the following key factors to these changes (see Table 1-1):

- Increases in sector **activity** lead to increased energy use and GHG emissions. Activity is defined differently in each sector. For example, in the residential sector, it is defined as the number of households and the floor space of residences. In the industrial sector, it is defined as industrial GDP, gross output and physical industrial output, such as tonnes of steel.
- Fluctuations in **weather** lead to changes in space-heating and space-cooling requirements. A colder winter or a warmer summer can lead to increased energy use.
- A shift in the **structure** of activity toward more energy-intensive components of activity leads to increased energy use and emissions. For example, if the distribution of activity in the industrial sector shifts from forestry to the iron and steel industry, industrial energy use will increase because the former sector is less energy intensive than the latter.
- **Service level** refers to the penetration rate of electrical devices and equipment, for example, the use of auxiliary equipment in commercial/institutional buildings and appliances in homes or the amount of floor space cooled.
- **Energy efficiency** effect indicates how effectively energy is being used, for example, the degree to which less energy is being used to provide the same level of energy service. Energy efficiency gains occur primarily with improvements in technology or processes. An example of such an improvement would be replacing incandescent lights with compact fluorescent lamps.

TABLE 1-1

Explanation of Changes in Secondary Energy Use, 1990 to 2008

	Sectors					
	Residential	Commercial/ Institutional	Industrial	Transportation	Total*	Change (%)
1990 energy use (PJ)	1 282.2	867.0	2 710.0	1 877.9	6 936.2	
2008 energy use (PJ)	1 465.3	1 205.9	3 237.8	2 594.1	8 720.2	
Change in energy use (PJ)	183.1	338.9	527.8	716.2	1 784.0	25.7
Source: oee.nrcan.gc.ca/corporate/statistics/neud/dpa/handbook_tables.cfm?attr=0						
Explanatory factor (change due to)						
Activity	465.7	322.5	1 331.4	823.7	2 943.3	42.4
Weather	25.0	9.3	n/a	n/a	34.3	0.5
Structure	10.5	-1.0	-471.1	219.6	-242.1	-3.5
Service level	73.5	111.5	n/a	n/a	185.0	2.7
Energy efficiency	-391.6	-103.6	-332.5	-378.2	-1 205.9	-17.4
Other factors		0.2		51.2	69.4	1.0

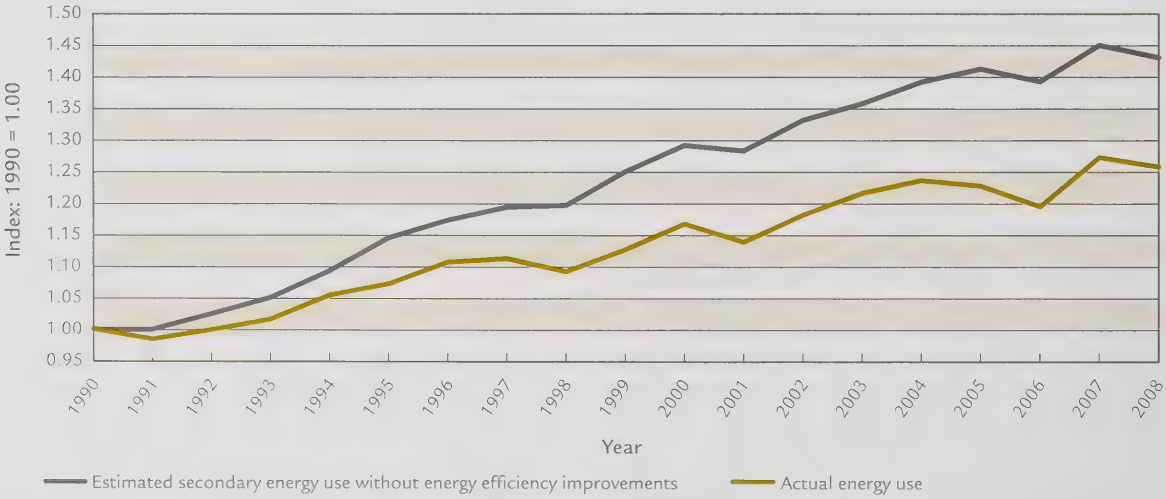
Source: oee.nrcan.gc.ca/corporate/statistics/neud/dpa/analysis_ca.cfm?attr=0
*Total also includes energy use for agriculture.

In this report, changes in energy efficiency are the net result after allowing for changes in energy use due to activity, weather, structure and service level. However, other factors, such as individual consumer choice, may affect energy use and are not captured by the above standardized factors. The effects of activity, weather, structure and service level may overstate or understate the "actual" change in energy use and energy efficiency improvements.

Between 1990 and 2008, secondary energy use in Canada increased from 6 936.2 PJ to 8 720.2 PJ. Without improvements in energy efficiency, increases attributable to activity, weather, structure and service level would have led to an energy increase of

FIGURE 1-4

Secondary Energy Use, Actual and Without Energy Efficiency Improvements, 1990 to 2008



Source: oee.nrcan.gc.ca/corporate/statistics/neud/dpa/analysis_ca.cfm?attr=0

43 percent. However, as a result of an 18 percent (1 205.9 PJ) improvement in energy efficiency,[4] actual secondary energy use increased by only 26 percent. This improvement in energy efficiency is estimated to have reduced GHG emissions by 67.3 Mt and decreased energy expenditures by $26.9 billion in 2008. The change in energy use between 1990 and 2008, actual and without energy efficiency improvements, is shown in Figure 1-4.

TRENDS IN RENEWABLE ENERGY

Canada is a leader in the production of renewable energy, with over 16.9 percent of its primary energy supply coming from renewable energy sources in 2009. Although renewable energy is often associated with electricity, renewable energy sources also produce thermal energy (heat) and transportation fuels. Renewable energy sources in Canada include inland and ocean water, wind, solar, geothermal and biomass.

Canada has a significant renewable electricity supply due primarily to the widespread use of hydroelectricity. In 2009, 61.7 percent of Canada's electricity generation was provided by large and small hydroelectric plants, which generated 366 terawatt hours (TWh) of electricity, down 2 percent from 374 TWh in 2008. Small hydro plants (less than 50 megawatts [MW]), with installed generating capacity of 3 372 MW, provided about 2.3 percent of the total electricity generation in Canada.

DID YOU KNOW?

Canada is a global leader in the generation of clean and renewable energy. We are the world's second largest producer of hydroelectricity, and more than three quarters of the electricity we generate produces no GHG emissions. Canada is also positioned first and ninth in the world for the installed capacity of solar air heating collectors and wind energy respectively.

In 2009, non-hydro renewable sources accounted for an estimated 2.7 percent of Canada's electricity generation. In terms of annual additions to the installed capacity, wind energy is the fastest-growing source of electricity in Canada, with an increase in capacity from 139 MW in 2000 to 3 319 MW in 2009. As of March 31, 2011, wind energy capacity was 4 825 MW, and its growth is expected to continue at a significant pace.

With 1 671 MW of installed capacity in 2009, biomass (waste and virgin biomass and landfill gas) remains one of the main non-hydro renewable energy sources in Canada.

Solar photovoltaic (PV) energy also experienced high rates of capacity growth – about 38 percent average growth rate annually between 1992 and 2010 – although it started from a very low baseline. So far, 2010 has been the best year for solar PV, with an estimated installed capacity of 290 MW, representing an increase of 196 MW from the previous year.

The Canadian active solar thermal installed capacity in 2010 was 1 025 600 square metres (m^2), which is approximately 712 megawatts thermal (MW_{th}). The domestic market increase has averaged 13 percent annually since 1998. In 2010, the solar thermal collector market in Canada was approximately 179 360 m^2, which was 38 percent more installations than in 2009 (130 000 m^2).

British Columbia and Nova Scotia are taking steps to support the development of the next generation of ocean renewable energy technologies, which use waves, ocean currents and tides to generate electricity.

In 2010, the Fundy Ocean Resource Centre for Energy, a technology demonstration facility, started testing three technologies with a total capacity of 4 MW. Wave and tidal-current technologies are also being tested off the coast of British Columbia, and a commercial facility for generating electricity may be feasible within the next decade.

In 2009, 15 643 ground-source heat pump (GSHP) units were installed in Canada. This compares

[4] Based on the OEE Index.

with 14 879 units installed in 2008 and 9 284 units installed in 2007. As of December 31, 2009, there were approximately 83 000 GSHPs representing about 1 000 MW_{th} of installed capacity and producing an estimated 1 370 gigawatt-hours equivalent annually.

As described in Chapter 5, in 2010–2011, NRCan carried out three initiatives – ecoENERGY for Renewable Power, ecoENERGY for Renewable Heat and the Pulp and Paper Green Transformation Program – to increase the use and production of renewable energy in Canada. In addition, the Investments in Forest Industry Transformation program supports projects promoting innovative technologies in the forest sector; alternative energy systems could thus qualify for funding through this program.

TRENDS IN RESIDENTIAL SECTOR

Energy Use and Greenhouse Gas Emissions

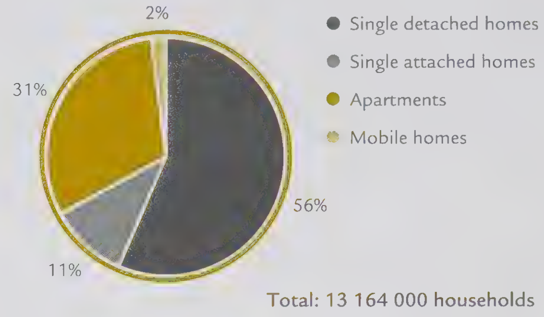
The residential sector includes four major types of dwellings: single detached, single attached, apartments and mobile homes. Energy is used in dwellings for space heating and cooling; water heating; and the operation of appliances, electronic equipment and lights. In 2008, this sector accounted for 17 percent (1 465.3 PJ) of secondary energy use and 15 percent (74.2 Mt) of GHGs emitted in Canada.

Most dwellings in Canada are single detached houses. The next largest type of dwelling is apartments, followed by single attached dwellings and mobile homes (see Figure 1-5). In 2010–2011, the OEE's ecoENERGY Retrofit – Homes and ecoENERGY for Buildings and Houses programs aimed to improve the energy efficiency of single detached and attached houses.

Between 1990 and 2008, residential energy use increased by 14 percent, or 183.1 PJ. Because homeowners gradually switched to cleaner energy sources (less GHG-intensive fuels), the associated GHG emissions grew only 8 percent during the same period.

FIGURE 1-5

Canadian Households by Type of Dwelling, 2008

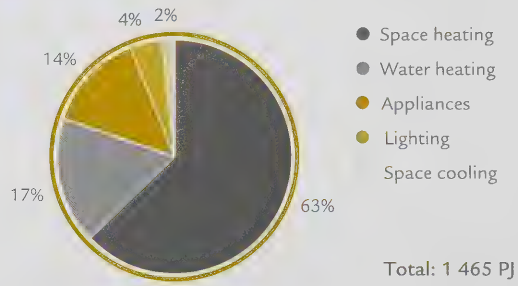


Source: oee.nrcan.gc.ca/corporate/statistics/neud/dpa/handbook_res_ca.cfm?attr=0

Energy intensity (gigajoules/household) decreased 14 percent despite the average household operating more appliances, becoming larger and increasing its use of space cooling. Space and water heating constituted 80 percent of residential energy use (which exhibited a small drop in space-heating energy use), followed by operating appliances, lighting and space cooling (see Figure 1-6).

FIGURE 1-6

Residential Energy Use by End Use, 2008



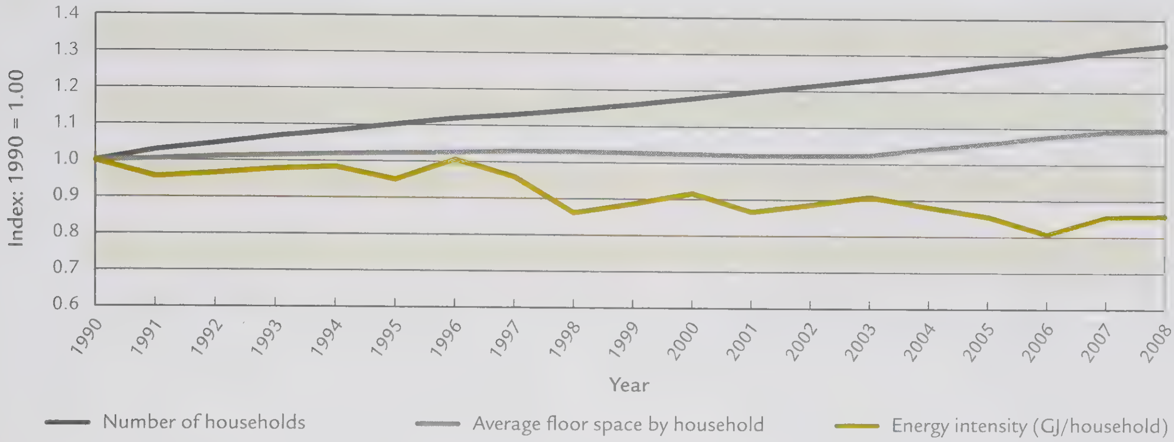
Source: oee.nrcan.gc.ca/corporate/statistics/neud/dpa/handbook_res_ca.cfm?attr=0

Five main factors influenced residential energy use between 1990 and 2008 – activity, weather, structure, service level and energy efficiency effect:

- Activity – As measured by combining a mix of households and floor space, energy use increased 36 percent (465.7 PJ). Growth in activity was driven by a 45 percent increase in floor area

FIGURE 1-7

Number of Households, Average Floor Space by Household and Energy Intensity Indexes, 1990 to 2008



Source: oee.nrcan.gc.ca/corporate/statistics/neud/dpa/analysis_ca.cfm?attr=0

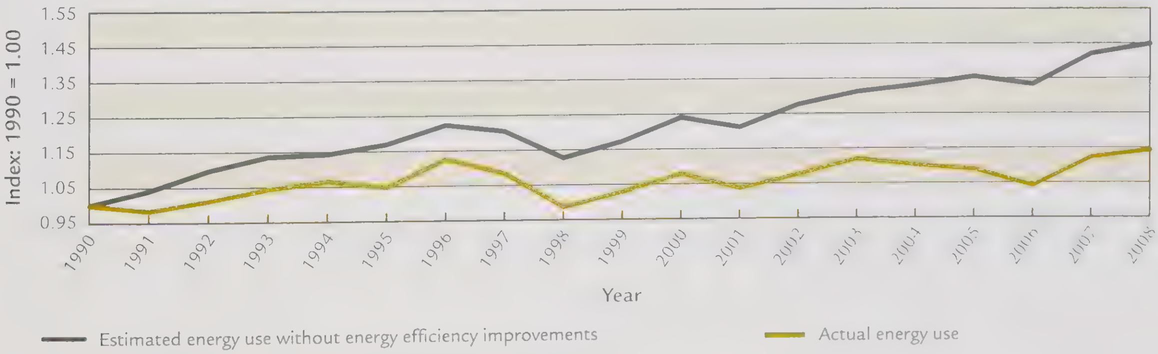
and by a rise of 33 percent in the number of households.

- Weather – In 2008, the winter was colder and the summer was warmer than in 1990. The net result was an overall increase in energy demand of 25.0 PJ.
- Structure – The increase in the relative share of single family houses resulted in the sector using an additional 10.5 PJ of energy.
- Service level – The increased penetration rate of appliances and the increased floor space cooled by space cooling units were responsible for 73.5 PJ of the increase in energy.
- Energy efficiency – Improvements to the thermal envelope of houses and to the efficiency of residential appliances and space- and water-heating equipment led to an overall energy efficiency gain in the residential sector. This efficiency gain saved 391.6 PJ of energy.

Growth in residential energy use was driven in large part by growth in activity. This growth in activity – specifically, growth in total floor space and number of households – was due to the increase in the average size of newly constructed houses, the rising population and the trend toward fewer individuals per household (see Figure 1-7).

FIGURE 1-8

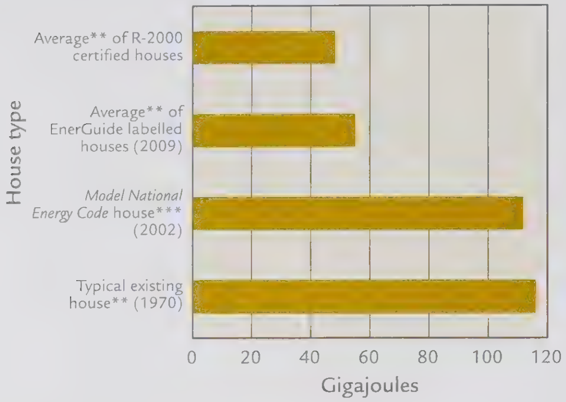
Residential Energy Use, Actual and Without Energy Efficiency Improvements, 1990 to 2008



Source: Natural Resources Canada, Residential End-Use Model, Ottawa, 2010.

FIGURE 1-9

Annual Heating* Consumption for Houses Constructed to Different Standards

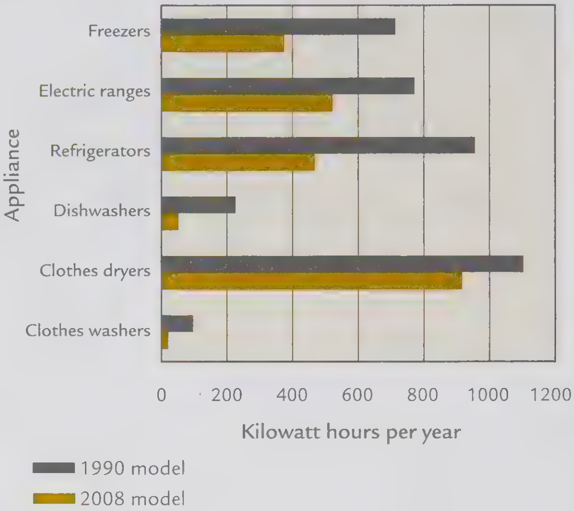


*DHW and space heating
**National average
***198 m², two-storey, single detached house heated with natural gas located in Ottawa, Ontario

Source: NRCan national housing database and internal data.

FIGURE 1-10

Average Energy Consumption of New Electric Appliances, 1990 and 2008 Models



Source: Natural Resources Canada, Residential End-Use Model, Ottawa, 2010.

These increases were partially offset by significant improvements in energy efficiency. Service level increased energy demand, because more Canadians cooled their homes during the summer months in 2008 than in 1990 and Canadians operated more appliances in 2008 than they did in 1990.

DID YOU KNOW?

Energy use for powering all household minor appliances more than doubled between 1990 and 2008. This 44.3-PJ increase was equivalent to the energy required to provide lighting to all Canadian homes in the mid-1980s.

Energy Efficiency

The change in residential energy use between 1990 and 2008 and the estimated energy savings due to energy efficiency measures are shown in Figure 1-8.

Overall, energy efficiency upgrades – including improvements to the thermal envelope (insulations, windows, etc.) and more energy-efficient appliances, furnaces and lighting – resulted in significant monetary savings for each Canadian household. The 31 percent improvement in energy efficiency between 1990 and 2008 translated into $8.2 billion in energy savings in 2008.

Figure 1-9 shows how energy consumption differs for houses built in different periods, reflecting improvements in building construction.

Figure 1-10 shows how average energy consumption of new appliances has improved, by comparing 1990 and 2008 models.

In 2010–2011, NRCan carried out the following initiatives to increase energy efficiency in the residential sector:

- ecoENERGY Retrofit – Homes
- ecoENERGY for Buildings and Houses
- Clean Energy Systems for Buildings and Communities
- ecoENERGY for Equipment

TRENDS IN COMMERCIAL/ INSTITUTIONAL SECTOR

Energy Use and Greenhouse Gas Emissions

The commercial/institutional sector includes activity related to trade, finance, real estate, public administration, education and commercial services. This sector uses energy mainly for space and water heating, operation of auxiliary equipment, space cooling and lighting, as well as operating auxiliary equipment (such as computers) and motors.

In 2008, the commercial/institutional sector accounted for 14 percent of secondary energy use and 13 percent of GHG emissions in Canada. Between 1990 and 2008, commercial/institutional energy use (including street lighting) increased by 39 percent, from 867 PJ to 1 205.9 PJ. GHG emissions from the sector rose by 38 percent in the same period. The increase in use of GHG-intensive fuels, such as heavy oil and light fuel oil, explains why GHG emissions grew at a faster pace than energy use.

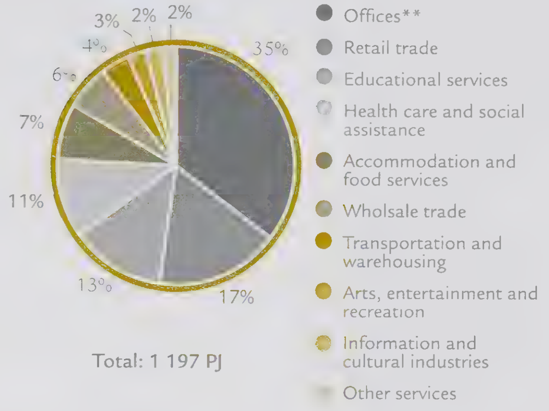
To highlight energy use in commercial/institutional activities, the following analysis excludes energy use for street lighting. The commercial/institutional sector comprises many activity types (see Figure 1-11). In 2008, offices accounted for 35 percent of the sector's energy demand. Retail trade (17 percent) and educational services (13 percent) were the next largest users.

Energy is used for seven purposes in commercial/ institutional activities. As illustrated in Figure 1-12, in 2008, the largest of these was space heating, which accounted for 48 percent of the energy use in the sector. Two other end uses have shown large increases in energy requirements: auxiliary equipment, resulting from increasing computerization of work spaces; and space cooling, resulting from the higher cooling rate of commercial/ institutional buildings.

Five main factors influenced commercial/institutional energy use between 1990 and 2008 – activity, weather, structure, service level and energy efficiency effect:

FIGURE 1-11

Commercial/Institutional Energy Use by Activity Type,* 2008



*Excludes street lighting

** "Offices" includes activities related to finance and insurance; real estate and rental and leasing; professional, scientific and technical services; and public administration.

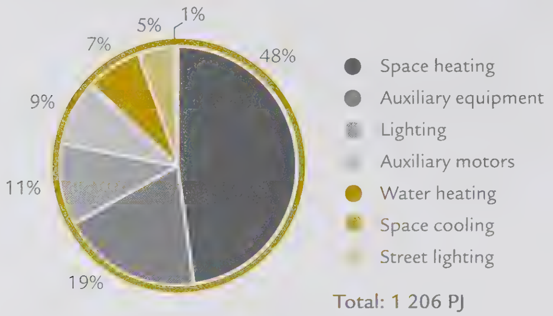
Source: oee.nrcan.gc.ca/corporate/statistics/neud/dpa/handbook_com_ca.cfm?attr=0

- Activity – A 37 percent increase in floor space led to a 38 percent (322.5 PJ) growth in energy use and an increase of 17.5 Mt in GHG emissions.
- Structure – The effect of structure changes in the sector (the mix of activity types) was small and therefore changed GHG-related emissions only marginally.
- Weather – In 2008, the winter was colder and the summer was warmer than in 1990. The net result was a 9.3-PJ increase in energy demand in the commercial/institutional sector, mainly for space conditioning, which had the effect of increasing GHG emissions by 0.5 Mt.
- Service level – An increase in space cooling and in the service level of auxiliary equipment, which is the penetration rate of office equipment (e.g. computers, fax machines and photocopiers), led to a 111.5-PJ increase in energy use and a 6.0-Mt increase in GHG emissions.

- Energy efficiency – Improvements in the energy efficiency of the commercial/institutional sector saved 103.6 PJ of energy and 5.6 Mt of related emissions.

FIGURE 1-12

Commercial/Institutional Energy Use by Purpose, 2008



Source: oee.nrcan.gc.ca/corporate/statistics/neud/dpa/handbook_com_ca.cfm?attr=0

Energy Efficiency

Gains in energy efficiency were made through improvements to the thermal envelope of buildings (insulation, windows, etc.) and increased efficiency of energy-consuming items, such as furnaces, auxiliary equipment and lighting, which slowed the rate of increase in energy use. Without improvements in energy efficiency, energy use in the commercial/institutional sector would have increased by 51 percent. However, actual energy use increased by only 39 percent between 1990 and 2008, resulting in energy savings of $2.4 billion in 2008.

Between 1990 and 2008, the estimated energy efficiency improvements resulted in energy savings of 103.6 PJ for this sector (see Figure 1-13).

In 2010–2011, NRCan carried out the following initiatives to increase energy efficiency in the commercial/institutional sector:

- ecoENERGY Retrofit – Small and Medium Organizations
- ecoENERGY for Buildings and Houses
- Clean Energy Systems for Buildings and Communities
- ecoENERGY for Equipment

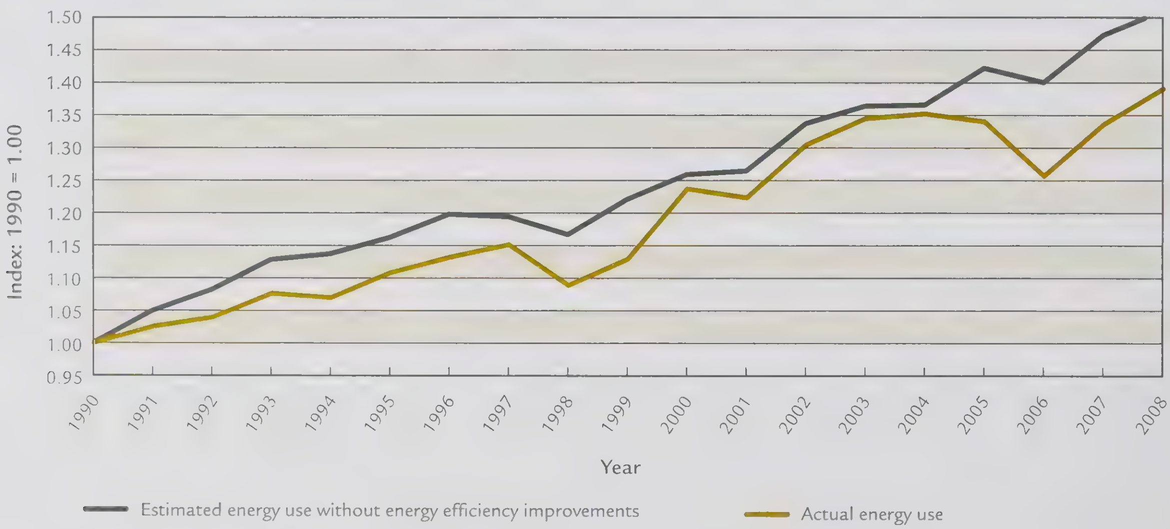
TRENDS IN INDUSTRIAL SECTOR

Energy Use and Greenhouse Gas Emissions

The industrial sector includes all manufacturing, mining (including oil and gas extraction), forestry and construction activities. However, it excludes

FIGURE 1-13

Commercial/Institutional Energy Use, Actual and Without Energy Efficiency Improvements, 1990 to 2008



Source: Natural Resources Canada, Commercial/Institutional End-Use Model, Ottawa, 2010.

electricity generation. This sector uses energy in industrial processes as a source of motive power and to produce heat or generate steam.

Overall, industrial energy demand in 2008 accounted for 37 percent (3 237.8 PJ) of secondary energy use and 32 percent (154.0 Mt) of GHG emissions (including electricity-related emissions). Between 1990 and 2008, actual industrial energy use increased by 19 percent, from 2 710.0 PJ to 3 237.8 PJ. The associated end-use GHGs increased 13 percent, from 136.0 Mt to 154.0 Mt.

In the industrial sector, energy was consumed primarily in mining, other manufacturing, pulp and paper production, and the petroleum refining industries. Mining alone accounted for 25.5 percent of total industrial energy demand in 2008 (see Figure 1-14).

In most industries, energy purchases accounted for only a small portion of total expenditures. However, for some relatively energy-intensive industries – cement, aluminum, pulp and paper, and iron and steel – this share was 9.9 percent or higher (see Figure 1-15). For cement, in particular, the share was 22.9 percent.

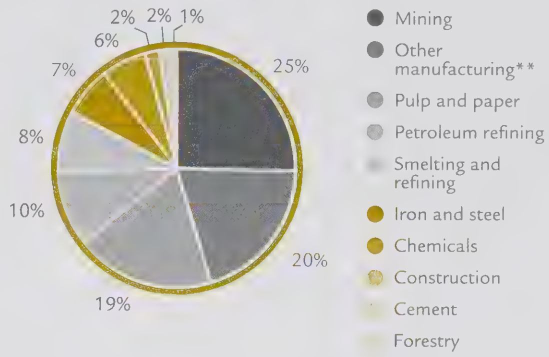
Between 1990 and 2008, industrial GHG emissions, including electricity-related emissions, increased by 13 percent. Excluding electricity-related emissions, industrial GHG emissions increased by 12 percent. Most of this increase in direct GHG emissions occurred in the upstream oil and gas industry. The pulp and paper industry, however, achieved a 42 percent decrease in GHG emissions.

Three main factors influenced industrial energy use between 1990 and 2008 – activity, structure and energy efficiency effect:

- Activity – The mix of GDP, gross output and production units (activity measures) increased the energy use by 49 percent, or 1 331.4 PJ.

FIGURE 1-14

Industrial Energy Use by Subsector – Including Electricity-Related Emissions,* 2008

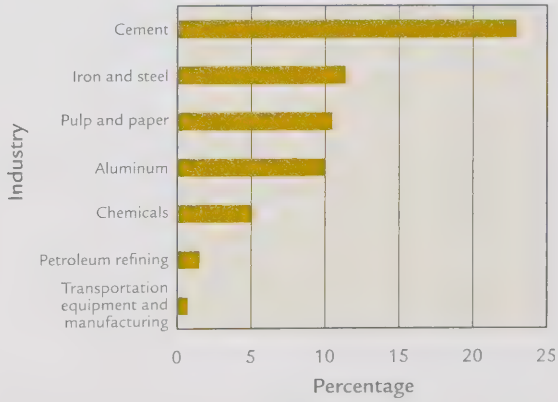


*The subsectors reflect the current definitions in the *Report on Energy Supply and Demand in Canada*.
** "Other manufacturing" comprises more than 20 manufacturing industries.
Source: oee.nrcan.gc.ca/corporate/statistics/neud/dpa/trends_agg_ca.cfm

- Structure – The structural changes in the industrial sector, specifically a relative decrease in the activity share of energy-intensive industries, helped the sector to reduce its energy use by 471.1 PJ.
- Energy efficiency – Improvements in the energy efficiency of the industrial sector avoided 332.5 PJ of energy use.

FIGURE 1-15

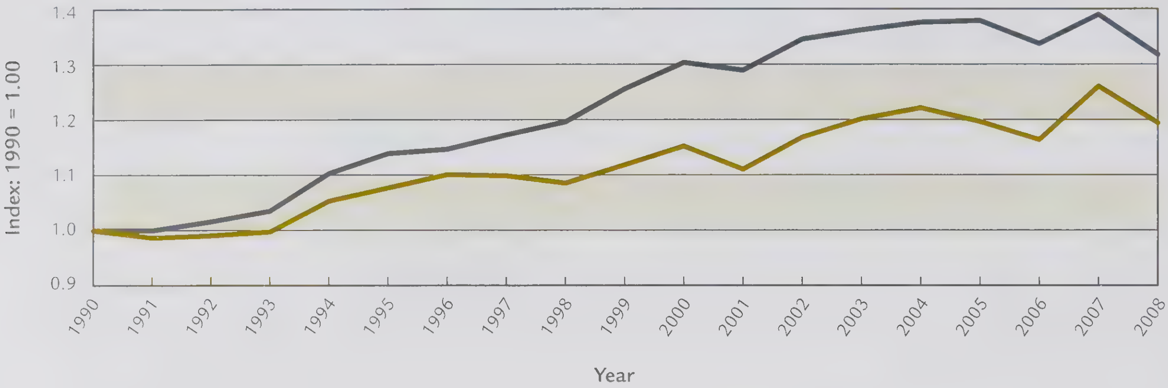
Cost of Energy to Manufacturing Industries as a Percentage of Total Production Cost, 2008



Source: Statistics Canada, CANSIM Table 301-0006.

FIGURE 1-16

Industrial Energy Use, Actual and Without Energy Efficiency Improvements, 1990 to 2008



Estimated energy use without energy efficiency improvements — Actual energy use

Source: Natural Resources Canada, Industrial End-Use Model, Ottawa, 2010.

Energy Efficiency

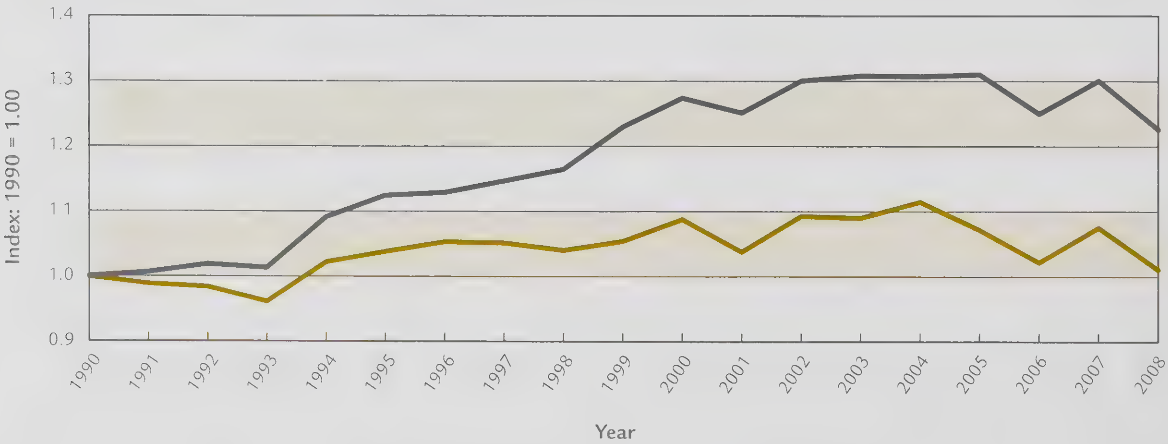
The change in energy use between 1990 and 2008 and the estimated energy savings attributed to energy efficiency are shown in Figure 1-16.

Energy efficiency improvements in the form of more efficient capital and management practices are important factors in managing energy use and decreasing energy intensity.

Since 1990, energy efficiency in the industrial sector has improved 12 percent. In 2008 alone, Canadian industry saved $4.3 billion in energy costs and 332.5 PJ of energy, or 15.8 Mt of GHG emissions. The improvement in energy efficiency was largely the result of improvements in energy intensity. The energy savings due to the energy efficiency improvements made by some industries were offset by increases in consumption by the upstream mining, fertilizer and forestry subsectors.

FIGURE 1-17

Industrial Energy Use, With and Without Energy Efficiency Improvements (Without Upstream Mining), 1990 to 2008



Estimated energy use without energy efficiency improvements — Actual energy use

Source: Natural Resources Canada, Industrial End-Use Model, Ottawa, 2010.

From 1990 to 2008, the upstream mining share of industrial energy use grew from 8 percent to 22 percent. This change reflects not only growth in production but also a shift from conventional to the significantly more energy-intensive unconventional oil production. Netting out the upstream mining, Canadian industries improved energy efficiency by 21 percent, which represents 535.8 PJ of savings (see Figure 1-17).

In 2010–2011, NRCan carried out the following initiatives to increase energy efficiency in the industrial sector:

- ecoENERGY Retrofit – Small and Medium Organizations
- ecoENERGY for Industry
- Clean Energy Systems for Industry
- ecoENERGY for Equipment

TRENDS IN TRANSPORTATION

Energy Use and Greenhouse Gas Emissions

In 2008, transportation was second to the industrial sector in terms of secondary energy use, accounting for 30 percent (2 594.1 PJ) of Canada's total secondary energy use and the largest portion of Canadian end-use GHG emissions at 37 percent (179.4 Mt).

Transportation accounts for a greater share of GHG emissions because the main fuels used by the sector are more GHG-intensive than those used in other sectors of the economy.

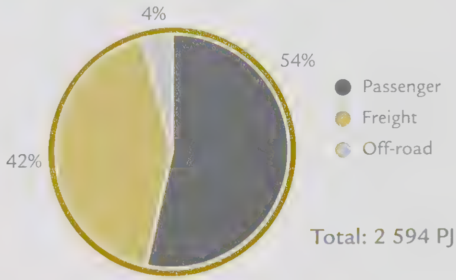
The transportation sector consists of three subsectors: passenger, freight and off-road. In 2008, passenger and freight transportation accounted for 54 percent and 42 percent of transportation energy use respectively, while off-road represented only 4 percent (see Figure 1-18). Owing to limitations in the available data and the small percentage it accounts for, the off-road subsector is not analysed in further detail.

The passenger subsector has three modes: road, rail and air. The freight subsector, as defined by NRCan, is composed of road, rail, air and marine modes. All of NRCan's transportation energy use programs focus on the energy used in road transportation. Between 1990 and 2008, total transportation energy use increased by 38 percent, from 1 877.9 PJ to 2 594.1 PJ, and the associated GHG emissions rose 36 percent, to 179.4 Mt. Within the transportation sector, passenger transportation energy use increased by 18 percent (212.4 PJ), while freight transportation energy use increased by 71 percent (454.5 PJ).

Three main factors influenced passenger transportation energy use between 1990 and 2008 – activity, structure and energy efficiency effect:

- Activity – The activity effect (i.e. passenger-kilometres [Pkm] travelled) increased energy use by 39 percent, or 445 PJ, with a corresponding 30.2-Mt increase in GHG emissions. Light truck and air transportation led the growth in Pkm (and therefore, activity effect), with respective increases of 157 percent and 96 percent.
- Structure – Changes to the mix of transportation modes, or the relative share of Pkm travelled by air, rail and road, are used to measure changes in structure. The popularity of minivans and sport utility vehicles (SUVs) increased the activity share of light trucks compared with other modes, contributing to a 27.7-PJ increase in energy

FIGURE 1-18
Transportation Energy Use by Mode, 2008



Source: oee.nrcan.gc.ca/corporate/statistics/neud dpa/handbook_tran_ca.cfm?attr=0

consumption and a 1.9-Mt increase in GHG emissions.

- Energy efficiency – Improvements in the energy efficiency of passenger transportation saved 262.2 PJ of energy and 17.8 Mt of energy-related GHG emissions. The light-duty vehicle segment (cars, light trucks and motorcycles) of passenger transportation represented 73 percent of these energy savings.

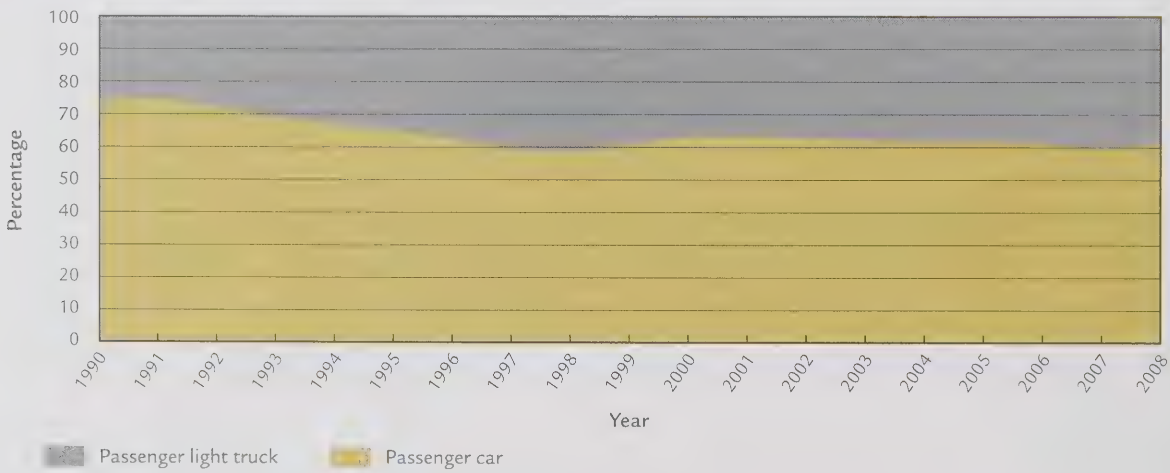
Three main factors influenced freight transportation energy use between 1990 and 2008 – activity, structure and energy efficiency effect:

- Activity – The activity effect (i.e. tonne-kilometres moved) increased energy use 59 percent, or 378.7 PJ, and caused a corresponding 26.8-Mt increase in GHG emissions. This increase in the number of tonne-kilometres was mainly due to an increase of 185 percent in heavy-trucks activity and an increase of 53 percent in medium-trucks activity.
- Structure – Changes to the mix of transportation modes – or the relative share of tonne-kilometres travelled by air, marine, rail and road – are used to measure changes in structure. Therefore, for example, an overall change in the structure would result in a decrease (increase) in energy use if a relative share of a more (or less) efficient transportation mode increases relative to other modes. Over the period, the shift between modes was the increase in the share of freight moved by heavy trucks relative to other modes. The overall effect on the structure was positive, given the increase in Canada-U.S. trade and the just-in-time delivery demanded by clients, thus contributing to a more intensive use of truck transportation. Therefore, the analyses show an increase of 191.9 PJ in energy use and an increase of 13.6 Mt in GHG emissions due to the structure effect.
- Energy efficiency – Improvements in the energy efficiency of freight transportation saved 116.1 PJ of energy and 8.2 Mt of GHG emissions. Improvements in freight trucks (light, medium and heavy trucks) were a large contributor, representing 51 percent of the savings.

Figure 1-19 shows how the market share of new light trucks increased in the 1990s, reflecting the increase in popularity of minivans and SUVs. Recently, however, this trend seems to have stabilized, with the share of light trucks remaining steady over the past few years. The higher share of heavier and more powerful passenger vehicles has had a significant effect on the increase in passenger energy use.

FIGURE 1-19

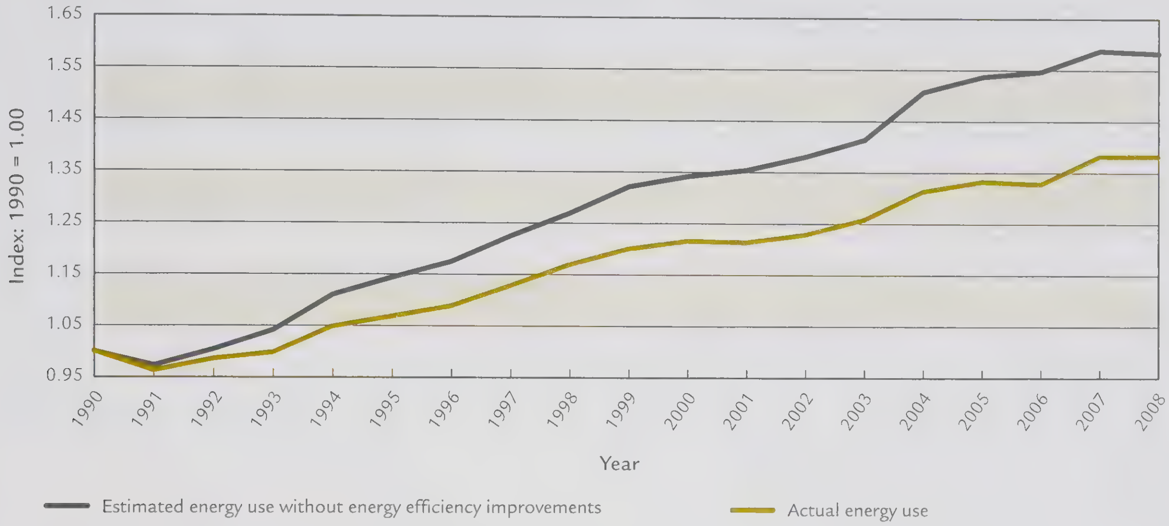
Market Shares of New Passenger Car and Light-Truck Sales, 1990 to 2008



Source: oee.nrcan.gc.ca/corporate/statistics/neud/dpa/handbook_tran_ca.cfm?attr=0

FIGURE 1-20

Transportation Energy Use, Actual and Without Energy Efficiency Improvements, 1990 to 2008



Source: oee.nrcan.gc.ca/corporate/statistics/neud/dpa/handbook_tran_ca.cfm?attr=0

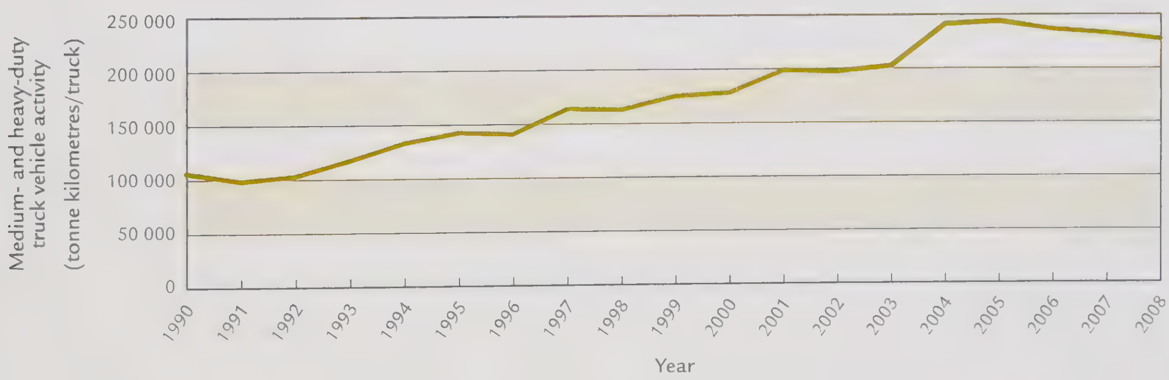
Energy Efficiency

Without improvements in energy efficiency, increases attributable to activity and structure would have led to an increase in transportation energy use of 58 percent. However, between 1990 and 2008, actual energy use increased by 38 percent. During this period, energy efficiency in the transportation sector improved by 21 percent, leading to a savings of $12 billion, or 378.2 PJ of energy. This change in energy use between 1990 and 2008 and the estimated energy savings due to energy efficiency improvements are shown in Figure 1-20.

Figures 1-21 and 1-22 illustrate an improvement in trucking energy intensity despite an increase in average activity from 1990 to 2008. Improved fleet practices, caused by an increase in the competitiveness of the transportation sector and by the introduction of electronic engines, have improved fuel efficiency in medium- and heavy-duty trucks.

FIGURE 1-21

Average Activity per Truck, 1990 to 2008



Source: oee.nrcan.gc.ca/corporate/statistics/neud/dpa/handbook_tables.cfm?attr=0

FIGURE 1-22

Trucking Energy Intensity, 1990 to 2008

Source: Natural Resources Canada, Transportation End-Use Model, Ottawa, 2010.

In 2010–2011, NRCan carried out the following initiatives to increase the efficiency of motor vehicle use:

- ecoENERGY for Personal Vehicles
- ecoENERGY for Fleets
- Clean Transportation Energy

TRENDS IN ALTERNATIVE AND RENEWABLE FUELS

Alternative and Renewable Fuels

Alternative transportation fuels are fuels used for transportation other than petroleum-based gasoline and diesel. Some alternative transportation fuels, such as ethanol and biodiesel, are renewable; others, such as propane and natural gas, are non-renewable. Other possible alternative transportation fuels include next-generation biofuels, coal-to-liquids, electricity and hydrogen.

Renewable fuel is a broad term covering a range of fuels made from renewable energy sources that are naturally replenished in a relatively short period. The sources include biomass, hydropower, geothermal energy, wind energy and solar energy.

Biofuel is a well-known category of renewable fuel and can be produced from a variety of sources. Two commercially available biofuels are ethanol and biodiesel. Conventional ethanol is produced from sugars or starches, and biodiesel production typically uses vegetable oils and animal fats. In Canada, ethanol is typically produced from corn and wheat, while canola oil, soy oil and tallow are relevant biodiesel feedstocks.

Gasoline vehicles manufactured since the 1980s can use up to 10 percent ethanol in gasoline. An increasing number of original equipment manufacturers are endorsing the use of lower biodiesel blends, for example, up to 5 percent in diesel engines. Under development are next-generation biofuels, such as cellulosic ethanol. These biofuels could be made from non-conventional sources, such as agricultural residues, forest residues and waste materials.

Renewable Fuels Production

Renewable fuels production in Canada has increased since the emergence of ethanol in Manitoba in the 1980s. Between 2005 and 2010, biofuel production capacity increased from 228 million litres to 1.69 billion litres: 1.49 billion litres of ethanol and almost 200 million litres of biodiesel. In 2010, approximately 1.38 billion litres of ethanol was produced, and ethanol use represented 4.29 percent

of gasoline sales (an increase of 0.68 percent from 2009).

Environment Canada announced that the *Renewable Fuels Regulations* – requiring gasoline producers and importers to have an annual average renewable fuel content of at least 5 percent based on the volume of gasoline produced and imported – came into force on December 15, 2010. The Regulations included provisions requiring an average of 2 percent renewable content in diesel fuel and heating oil, subject to technical feasibility. Technical feasibility was demonstrated, and the 2 percent regulation and the coming-into-force date for the requirement is July 1, 2011.

In 2010–2011, NRCan carried out initiatives to increase the use and production of renewable and alternative fuels under the following programs:

- ecoENERGY for Biofuels
- Sustainable Development Technology Canada's NextGen Biofuels Fund™

Natural Gas Use in the Canadian Transportation Sector: Deployment Roadmap

Facilitated by NRCan, the *Natural Gas Use in Transportation Deployment Roadmap* brought together stakeholders representing government, industry, end-users, academia and environmental organizations to identify the optimal use of natural gas across the medium- and heavy-duty portions of the transportation sector.

The Roadmap work culminated in a comprehensive report that includes 10 recommendations stemming from business modelling, consultation with end-users and an investigation of research and development needs. These recommendations cover four key areas: de-risking investment and early adoption, addressing information gaps, increasing capacity to sustain markets, and ensuring ongoing competitiveness. The final report is available online at oee.nrcan.gc.ca/transportation/alternative-fuels/resources/2888.

CHAPTER 2

Equipment, Standards and Labelling

INTRODUCTION

Natural Resources Canada's (NRCan's) wide range of energy efficiency initiatives includes standards and labelling programs that are based on the requirements of Canada's *Energy Efficiency Regulations* (the Regulations).

The *Energy Efficiency Act* (the Act) of 1992 gives the Government of Canada the authority to make and enforce regulations that prescribe standards and labelling requirements for energy-using products that are imported to Canada or shipped across provincial borders for lease or sale. The Act was amended in 2009, making it possible to prescribe standards not only for more products that use energy but also for products, such as thermostats, that affect energy use. The Regulations came into effect in February 1995, after extensive consultations with provincial governments, affected industries, utilities, environmental groups and others. Since then, the Regulations have been amended a number of times.

Regulations have now been established for more than 40 products, including major household appliances, water heaters, heating and air-conditioning equipment, automatic icemakers, dehumidifiers, dry-type transformers, electric motors, commercial refrigeration and some lighting products. The Regulations apply to these products even if they are incorporated in a larger unit or machine that is not regulated.

The performance standards contained in the Regulations and accompanying labelling requirements and programs make a major contribution to the Government of Canada's Clean Air Regulatory Agenda. In October 2006, a notice of intent was published for amending the Regulations to prescribe standards for 20 new products and increase the stringency of existing standards for 10 products by 2010. When all the standards are implemented, there will be a standard in place for products that use 80 percent of the energy consumed in the residential and commercial/institutional sectors.

NRCan regularly amends the Regulations to strengthen the minimum energy performance requirements for prescribed products when the market has achieved a higher level of efficiency. The Regulations are also amended to add new products, harmonize minimum energy performance requirements with those of other jurisdictions and update testing methodologies and labelling requirements.

In addition, regulations can be established for gathering market data on the energy performance of certain types of equipment. For example, the data gathered for gas fireplaces are used to support programs developed by the industry and NRCan and its partners for gas fireplace performance.

Before amending the Regulations, NRCan conducts studies to determine how a proposed change will affect the market. A key criterion for amending the Regulations is that the change must have a significant positive impact on consumers and the environment. Stakeholders are consulted on all proposed changes to the Act and the Regulations, as well as on their practical application in the marketplace.

The Act and the Regulations also support labelling initiatives. These initiatives are designed to

help consumers and the commercial/industrial procurement community identify and purchase energy-efficient equipment that will save them money and reduce greenhouse gas (GHG) emissions over the life of the product.

The Act and the Regulations require that a comparative EnerGuide label be displayed on major electrical household appliances and room air conditioners or, as in the case of the newly implemented requirement for light bulb labelling, on the product packaging. The EnerGuide label shows the energy performance of the product and compares it with the most and least efficient models of the same class and size.

The EnerGuide label is also used voluntarily by manufacturers and suppliers of residential oil and gas furnaces, vented gas fireplaces, central air conditioners and air-to-air heat pumps. In this case, the EnerGuide rating for a specific product is published on the back page of the manufacturer's brochure. These ratings include the annual fuel utilization efficiency rating for oil and gas furnaces, the fireplace efficiency rating for gas fireplaces and the seasonal energy efficiency ratio for central air conditioners.

The ENERGY STAR® Initiative in Canada works with and complements the Regulations and comparative EnerGuide label. The internationally recognized ENERGY STAR symbol is a simple way for consumers to identify products that are among the most energy-efficient on the market.

Products that are prescribed in the Regulations and are also part of ENERGY STAR must meet levels of energy efficiency significantly above the minimum performance levels set out in the Regulations to qualify for the ENERGY STAR symbol. As higher-performance products penetrate the market, their efficiency levels trigger the development of new minimum energy performance standards.

STANDARDS

As a world leader in the use of energy efficiency standards, NRCan is committed to harmonizing standards and labelling requirements with those developed in other jurisdictions. Harmonization reduces barriers to trade and sustainable development by improving the flow of energy-efficient products within Canada and around the world. This practice minimizes the regulatory burden on manufacturers and avoids confusion for consumers.

For example, the performance requirements in the Regulations are similar to those in the six Canadian provinces that currently regulate energy-using equipment manufactured and sold within their borders. This alignment is achieved because governments support and participate in the development of national, consensus-based performance standards by accredited standards-writing organizations, such as the Canadian Standards Association.

Such standards include testing procedures that are used to determine a product's energy performance and are usually referenced federally and provincially. NRCan works closely with provinces throughout the regulatory process to ensure that the federal and provincial standards regimes are harmonized to the maximum extent possible.

Because the North American market is highly integrated, Canada's energy performance requirements for many products are strongly aligned with regulations in the United States. Canada is an active participant in international and regional forums, such as the U.S.-Canada Clean Energy Dialogue and the Clean Energy Ministerial. Both of these efforts contribute to regional co-operation on energy efficiency issues.

NRCan is also involved with the International Energy Agency's Efficient Electrical End-use Equipment (4E) initiative that facilitates co-operation among various Organisation for Economic Co-Operation and Development (OECD) countries on specific projects. Canada is participating in a mapping

and benchmarking study as well as one on standby power.

In 2009, an amendment to the *Energy Efficiency Act* broadened the scope of the Report to Parliament by the Minister of Natural Resources, as follows:

- Once every three years, "the Minister shall demonstrate the extent to which the energy efficiency standards prescribed under this Act are as stringent as comparable standards established by a province, the United Mexican States, the United States of America or a state of the United States of America."
- Within four years, the Minister shall "...demonstrate the extent to which energy efficiency standards have been prescribed under this Act for all energy-using products whose use has a significant impact on energy consumption in Canada."

A 2011 internal analysis addressed the first requirement by evaluating the minimum energy performance standards (MEPS) for Canada's 40 federally regulated products in effect as of March 31, 2011, and comparable standards in 21 jurisdictions (in the provinces, in Mexico and at federal and state levels in the United States). The analysis determined the differences in the level of stringency among these jurisdictions. (The second reporting requirement by the Act will be provided in the 2011–2012 Report to Parliament.)

Of the 21 jurisdictions reviewed, only 9 have regulations that are comparable with those in Canada (see Table 2-1). These jurisdictions are Mexico, United States, California, British Columbia, Quebec, New Brunswick, Nova Scotia, Manitoba and Ontario. The other 12[5] jurisdictions were U.S. states. While there has been significant standards-making in American states, Canada is closely aligned with U.S. federal standards, which pre-empt state standards. Consequently, the stringency comparison was made on a national basis except where states have standards and the U.S. Government does not.

[5] Arizona, Connecticut, Maryland, Nevada, New Hampshire, New York, New Jersey, Oregon, Rhode Island, Washington, Massachusetts, Vermont

TABLE 2-1

Comparison of the Stringency of Canada's Standards (as of March 31, 2011)

	United States	Mexico*	B.C.	Ont.	Que.	Man.	N.S.	N.B.	Calif.**	Total
Canada's standards are equivalent	27	7	10	23	6	0	22	19	2	116
Canada's standards are more stringent	4	1	17	9	14	0	10	14	1	70
Canada's standards are less stringent	4	2	3	1	0	2	1	1	1	15
Total standards available for comparison	35	10	30	33	20	2	33	34	4	201
Standards not comparable with Canada's standards	5	29	10	7	20	38	7	6	2	124
Percentage of Canadian standards at least as stringent as comparable standards***										93%

* Column sums to 39 instead of 40 due to difference in energy measurement of residential gas water heaters.

** Column does not sum to 40 due to products being covered under federal standards.

*** Calculated by summing over all jurisdictions the total number of standards for which Canada's MEPS are equivalent or more stringent (rows 1 and 2 of the table) and dividing by the total number of standards summed over all jurisdictions (rows 1, 2 and 3 of the table).

Approximately 93 percent of the standards prescribed under the Act are at least as stringent as comparable standards established by a province, Mexico, the United States and California. For example, Canada has standards that are equivalent in stringency to 116 standards in the United States, including California; Mexico; and six Canadian provinces. Of the remaining 7 percent prescribed under the Act, Canada has proposed equivalent or more stringent standards for more than half of the products. For further information, contact equipment@nrcan-rncan.gc.ca.

COMPLIANCE AND ENFORCEMENT

The Regulations outline a number of responsibilities for dealers who import to Canada, or ship from one Canadian province to another for the purpose of sale or lease, any prescribed energy-using product. NRCan is committed to securing voluntary compliance but can use enforcement measures when necessary. NRCan emphasizes self-monitoring, reporting, voluntary compliance and collaboration. However, the Act prescribes specific enforcement measures when dealers violate the law.

Enforcement activities include preventing the importation of non-compliant products to Canada, preventing the sale or lease of non-compliant products in Canada and imposing fines. Violators can also be fined under the Administrative Monetary Penalty System of the Canada Border Services Agency for not providing required information on the prescribed product at the time of import; serious violations can be prosecuted.

To monitor compliance with the Regulations, NRCan captures information from energy efficiency reports and import documents. Section 5 of the Act requires dealers to provide energy efficiency reports when they market a new product model. The required information includes the energy performance of each model, the name of the certification body that verified the energy performance of the product and the size category, as described in Schedule IV of the Regulations.

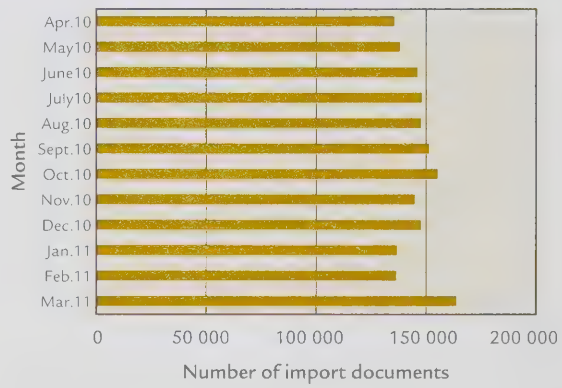
The Regulations require that when importing a regulated product into Canada, dealers provide specific product information on customs documents for all shipments (i.e. type of product, brand name, model number, address of dealer and purpose of import). A customs document contains less information than an energy efficiency report, but there is enough to allow NRCan to verify that there is a matching energy efficiency report. NRCan can then confirm that all products entering Canada meet the required energy performance levels and can take action when necessary.

NRCan processed more than 1.75 million records (records from April 1, 2010, to March 31, 2011) relating to the importation of regulated energy-using products to Canada in 2010–2011.

Figure 2-1 illustrates the volume of import documents received, in paper form and electronically, per month during the 2010–2011 fiscal year.

FIGURE 2-1

Volume of Monthly Import Documents



Source: OEE Equipment Database.

More than 2.4 million new or revised model numbers were submitted to NRCan for entry into NRCan's equipment database (records from April 1, 2010, to March 31, 2011) from dealers' energy efficiency reports.

REGULATORY IMPACT TO DATE FROM THE REGULATORY IMPACT ANALYSIS STATEMENT

In preparing amendments to the Regulations, NRCan analyses the impact of the proposed amendment on society, the economy and the environment. This information is made available through the Regulatory Impact Analysis Statement, which is annexed to the Regulations and published in the *Canada Gazette, Part II*.

It is estimated that Canada's energy performance standards from the 11 amendments have resulted in a reduction of 26.03 megatonnes (Mt) in aggregate annual GHG emissions (see Table 2-2).

During 2010–2011, NRCan conducted the analysis and consultation necessary to implement the remaining standards identified in the Clean Air Regulatory Agenda (CARA). Standards contained in Amendment 11 were pre-published in June 2010. Analysis to support a revision to the implementation dates for standards for light bulbs was also completed and pre-published in April 2011.

In total, the final 2020 CARA-projected energy efficiency impacts of the published and soon-to-be pre-published amendments (amendments 10–13) plus market transformation programs (including the proposed light-bulb delays and the removal of room air conditioning and portable air conditioning) are savings of 111.56 PJ of energy and 11.75 Mt of GHG emissions.

LABELLING AND PROMOTION

Since 1978, the EnerGuide label (see Figure 2-2) has given Canadians the opportunity to compare the energy consumption of appliances. In 1995, with the introduction of the Regulations, placing an EnerGuide label on major electrical household appliances and room air conditioners became mandatory. The label on a product shows how much energy a product uses, allowing the customer to consider the most energy-efficient choice.

EnerGuide directories that list energy ratings for major appliances and room air conditioners

TABLE 2-2

Estimated Impact of *Energy Efficiency Regulations*, 2010 and 2020 (Aggregate Annual Savings)

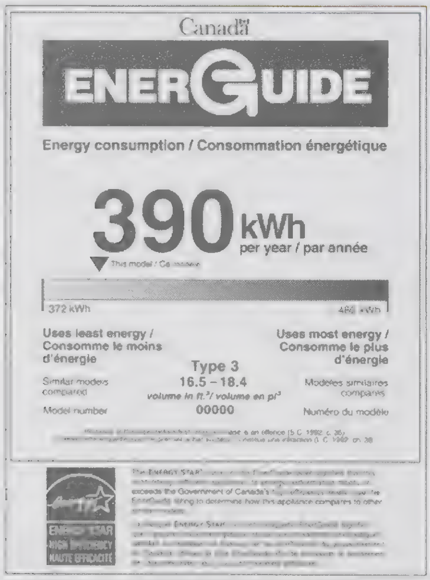
Product (amendment number in brackets)	Energy savings (PJ)		GHG reductions (Mt)	
	2010	2020	2010	2020
Residential appliances (1)	117.20	133.84	13.26	15.60
Lamps – fluorescent/incandescent (2)	11.60	13.40	7.55	9.80
Motors (3)	16.30	17.70	2.03	2.14
Commercial HVAC (4)	6.40	7.50	0.43	0.57
Refrigerators (5)	4.92	10.96	0.25	0.67
Ballast/room A/C, PAR lamps (6)	3.96	9.44	0.60	1.20
Clothes washers, domestic hot water, exit signs, chillers (8)	16.12	42.59	1.28	3.60
A/C, commercial refrigeration (9)	1.64	5.51	0.16	0.55
General service lighting, commercial and industrial gas unit heaters, traffic and pedestrian signals, ceiling fan lighting, torchiere lamps, commercial clothes washers, residential wine chillers, commercial ice-makers, residential dishwashers, residential dehumidifiers, residential gas furnaces (10)	6.09	88.10	0.40	9.67
Residential boilers, dry-type transformers, commercial three-phase induction motors, external power supplies, large air conditioners and heat pumps, room air conditioners, standby power, commercial reach-in refrigerators, digital television adaptors, residential general service incandescent reflector lamps, industrial three-phase induction motors, commercial general service incandescent reflector lamps (11)	0.55	7.50	0.07	0.96
Total	**184.77**	**336.53**	**26.03**	**44.76**

are published annually. They are distributed to consumers, retailers and appliance salespeople. In fulfilling requests for information, electric utilities and provincial governments also distribute the directories. Online directories for all appliances and heating and cooling equipment are published on the Web site of the Office of Energy Efficiency (OEE) and updated monthly.

A voluntary EnerGuide rating program was established in 1997 and included gas furnaces, central air conditioners, heat pumps and oil furnaces. In the fall of 2003, gas fireplaces were added to the EnerGuide rating program, and manufacturers were asked to include EnerGuide ratings for fireplace efficiency in their brochures. These changes coincided with the mandatory requirement in the Regulations to test, verify and report on fireplace efficiency.

Major distributors of these products for sale in Canada report the verified energy performance rating of their products, as tested against the standards in the Regulations. In addition, participants in the voluntary EnerGuide rating program must provide shipment data and aggregate energy efficiency

FIGURE 2-2
EnerGuide Label



information to track the progress of the program and identify marketplace improvements that can result from labelling.

Given that the equipment products listed above are typically purchased from a brochure or catalogue, a consumer would likely not read the EnerGuide label before making a decision to buy. Accordingly, manufacturers are encouraged to include an EnerGuide rating in product brochures and catalogues, so consumers can compare the efficiency of products when they are in the buying process. To date, manufacturers of 85 percent of eligible products on the market voluntarily participate in the EnerGuide rating program and publish the ratings in their brochures. Regularly conducted polls indicate that more than 50 percent of Canadians surveyed are aware of the EnerGuide label.

In 2001, responding to public interest in a labelling system that identifies the best performers, Canada officially introduced ENERGY STAR, the international symbol for energy efficiency (see Figure 2-3). Canada signed an agreement with the U.S. Environmental Protection Agency and the U.S. Department of Energy. Canada joins other international ENERGY STAR program participants: Australia; New Zealand; Japan; Taiwan; and the European Union, which adopted ENERGY STAR for office equipment. The OEE is the custodian of the program for Canada.

FIGURE 2-3
ENERGY STAR® Symbol

ENERGY STAR establishes high efficiency criteria and levels for selected products for the residential and commercial sectors. Product categories are selected on the basis of their technical potential for high

efficiency. This is a voluntary program. However, organizations must demonstrate that products meet the eligibility criteria and performance levels. For appliances and heating and cooling products, the criteria are based on the same test standards as those applied under the Regulations. Canada promotes specific product categories for which levels and criteria can be harmonized with those of the United States, including the following:

- major electrical appliances
- heating, cooling and ventilation equipment
- consumer electronics
- office equipment
- windows, doors and skylights (Canadian levels)
- selected lighting products – compact fluorescent lamps (CFLs), fixtures, decorative light systems and solid-state lighting
- selected commercial equipment, including commercial kitchen products

Canada has integrated ENERGY STAR with the EnerGuide label for qualified major appliances and room air conditioners, to help consumers identify the best-performing products. While the EnerGuide label shows how much energy a product uses under normal conditions in one year, the ENERGY STAR symbol on the label identifies the most energy-efficient product. Now that industry-accepted standards of high efficiency have been established, ENERGY STAR has become the criterion to meet for incentive and rebate programs and is used by many electrical and gas utilities across Canada. For example, Hydro-Québec, BC Hydro and the Ontario Power Authority had retailer incentive programs for ENERGY STAR qualified televisions. Enbridge Gas and Manitoba Hydro ran incentive programs for ENERGY STAR qualified commercial kitchen equipment.

ENERGY STAR is also the qualifying criterion for sales tax exemptions in Saskatchewan for the purchase of furnaces and boilers and in Ontario for ENERGY STAR qualified geothermal heating equipment. Organizations across Canada have used ENERGY STAR as a campaign driver to promote replacement with, or purchase of, higher efficiency products.

Continuous promotion of ENERGY STAR qualified appliances has paid off. Industry statistics for 2009 show an increase in market penetration from almost nil in 1999 to 53 percent for refrigerators, 69 percent for clothes washers and 90 percent for dishwashers (see Figure 2-4). The increase in market penetration indicates growing acceptance of ENERGY STAR as the brand for high energy efficiency and manufacturers' willingness to raise the efficiency of their products to qualifying levels.

ENERGY STAR specifications and levels are periodically updated as product saturation is reached, to encourage industry to strive for more efficient products and thus maintain the relevance and credibility of the brand.

ENERGY STAR is also well known in the commercial sector, with criteria for products ranging from office equipment to vending machines. NRCan supports demonstration projects to validate the savings and other benefits of some of these products and to address barriers to their widespread acceptance.

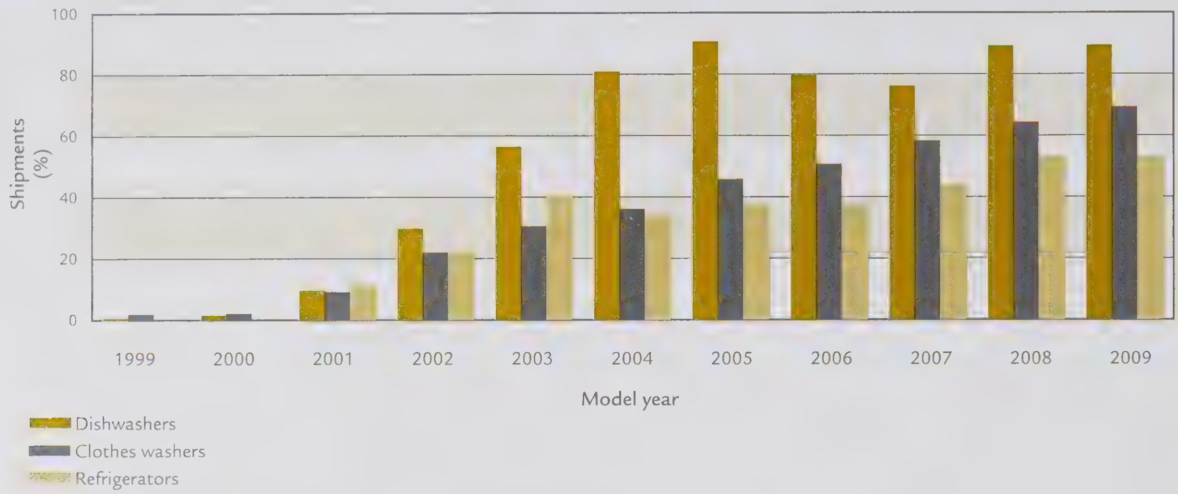
Canada continues to promote ENERGY STAR guidelines in its contacts with the procurement community. It has updated an interactive cost calculator that compares energy cost savings and GHG emissions reductions associated with the purchase of ENERGY STAR qualified products.

Workshops were held across Canada to make governments and institutions aware of the ENERGY STAR criteria and procurement tools. Dalhousie University was the first university in Canada to become an ENERGY STAR participant.

Canada is also working with housing agencies to help them identify energy savings in their properties and to specify ENERGY STAR qualified products for replacement equipment. Canada continues to expand the range of product types included in its ENERGY STAR agreement.

FIGURE 2-4

Distribution of ENERGY STAR Qualified Shipments of Appliances, 1999 to 2009



Source: *Energy Consumption of Major Household Appliances Shipped in Canada, Summary Report. Trends for 1990–2009.*

NRCan developed a rating and labelling system for efficient refrigeration applications in ice and curling rinks under the name CoolSolution.[6] An ice rink application is qualified CoolSolution if it achieves a rating higher than 50 percent. An incentive program to encourage the adoption of CoolSolution and reduce the initial payback of the first applications started in November 2006. Partnerships to accelerate the program have been successful.

CoolSolution designates innovative technologies and practices and consists of three main elements:

- heat recovery from the refrigeration system to meet all the building's heating requirements (e.g. hot air, hot water) or to export this energy for other purposes.
- adaptation to the Canadian climate by taking advantage of the naturally occurring cold temperatures. This is done by varying the temperature of the heat released into the environment according to the outdoor temperature.
- reduction of the synthetic refrigerant charges of the refrigeration system, which have a serious adverse impact on climate change. This is done by using natural refrigerants or by confining the synthetic refrigerant to the mechanical room and using environmentally friendly fluids to remove and distribute heat.

ecoENERGY FOR EQUIPMENT

Objective

To exclude the least efficient energy-using equipment from the market and to influence consumers to select – and manufacturers to produce – energy-efficient products that perform above minimum standards.

Description

The ecoENERGY for Equipment program is focused on accelerating the introduction of energy-efficient products in Canada's equipment stock. The program implements minimum energy efficiency performance standards that restrict the importation and interprovincial shipment of the least efficient products for sale in Canada. It also carries out

[6] CoolSolution is an official mark of Her Majesty the Queen in the Right of Canada as represented by the Minister of Natural Resources.

initiatives to increase the market share of more efficient products.

ecoENERGY for Equipment also supports labelling programs that encourage the introduction of more efficient technologies. This involves the establishment and promotion of high-efficiency performance criteria, such as ENERGY STAR, and the engagement of stakeholders to promote products that meet these criteria. As products are adopted in the marketplace, the ENERGY STAR or equivalent performance level will become the basis for new, more stringent standards. In addition, ecoENERGY for Equipment maintains a multilayered compliance and enforcement program to ensure that products meet prescribed standards and to ensure that other regulatory requirements, such as labelling, are met.

DID YOU KNOW?

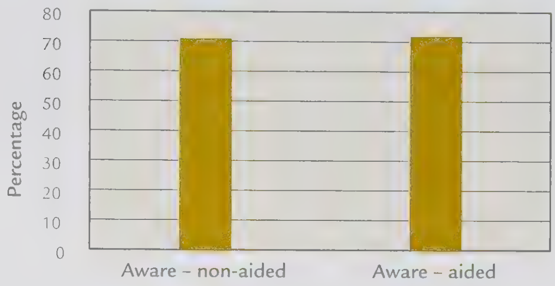
In a typical household, two televisions and associated service-provider hardware consume more electricity than two ENERGY STAR qualified refrigerators. Seventy-one percent of Canadians recognized the ENERGY STAR symbol unaided (see Figure 2-5), and 89 percent recognized the symbol when it was shown to them in an on-line survey.

Program components include the following:

- regulations under the *Energy Efficiency Act* (the Act) requiring dealers to ship only products that meet the prescribed energy efficiency standards
- the EnerGuide program, which rates and labels the energy efficiency of major household electrical appliances and heating, ventilating and air-conditioning equipment, assisting consumers in making energy-wise purchases
- the ENERGY STAR high-efficiency program, which is an international initiative that identifies the most energy-efficient products in their class

FIGURE 2-5

ENERGY STAR® Awareness Levels in Canada, 2010



Source: Tracking Study: Awareness of ENERGY STAR / EnerGuide Symbols 2010, Ipsos Reid.

Key 2010–2011 Achievements

- NRCan, in co-operation with the Canadian Electricity Association, utility providers and retailers across Canada, led the ENERGY STAR® Light Fixture campaign to demonstrate easy and practical ways that Canadian families can save energy, save money and help protect the environment. ENERGY STAR qualified fixtures use one quarter of the energy of traditional light fixtures and come in hundreds of styles.
- Carried out the work necessary to publish Amendment 11 to the *Energy Efficiency Regulations*. This amendment increases the stringency and/or scope of existing MEPS for seven currently regulated products and introduces new MEPS and associated reporting and compliance requirements for five products. It is estimated that this amendment will result in 0.97 Mt of annual GHG emission reductions in 2020 and represent $2 billion of net present value over the lifetime of the products shipped by 2020.
- Conducted the analysis and consultation necessary to pre-publish Amendment 13 to the *Energy Efficiency Regulations*. This amendment will increase the stringency and/or scope of existing MEPS for eight currently regulated products and introduce MEPS and/or associated reporting and compliance requirements for seven products. NRCan estimates that this proposed amendment will result in reductions of approximately 1 Mt of GHG emissions in 2020, increasing to

approximately 3 Mt in 2030. The net present value of benefits for all Canadians is estimated to be $762 million over the service life of products shipped by 2030 and $1.4 billion by 2030.

- Ten ENERGY STAR technical specifications were published and implemented, twice the targeted number. Examples include televisions, windows, doors, audio/DVD products and integral light-emitting diode (LED) lamps. In addition, the groundwork has been laid for introducing the Most Efficiency category of ENERGY STAR qualified products.
- Delivered five specialized workshops on the use of the ENERGY STAR calculator and on other ENERGY STAR related guidance to the procurement and institutional community.

For more information:

oee.nrcan.gc.ca/residential/energystar-energuide-r2000.cfm?attr=0

regulations.nrcan.gc.ca

CHAPTER 3 Energy Efficiency and Alternative Transportation Fuels

Natural Resources Canada's (NRCan's) Office of Energy Efficiency (OEE) aims to strengthen and expand Canada's commitment to energy efficiency in all sectors and increase the production and use of alternative transportation fuels in Canada. The OEE managed the ecoENERGY Efficiency Initiative, under the ecoENERGY suite of programs initiated on April 1, 2007. The ecoENERGY Efficiency Initiative included the following programs:

- ecoENERGY Retrofit
- ecoENERGY for Buildings and Houses
- ecoENERGY for Industry
- ecoENERGY for Personal Vehicles
- ecoENERGY for Fleets
- ecoENERGY for Equipment (see Chapter 2)

In addition, the OEE managed the ecoENERGY for Biofuels program, the National Renewable Diesel Demonstration Initiative and the Federal Buildings Initiative.

This chapter describes the objective of each of the aforementioned programs and outlines key achievements.

ecoENERGY RETROFIT

Objective

To provide incentives for energy efficiency improvements in homes and in small and medium-sized organizations in the institutional, commercial and industrial sectors. The program had two components:

- ecoENERGY Retrofit – Homes
- ecoENERGY Retrofit – Small and Medium Organizations

For more information:
oee.nrcan.gc.ca/retrofit

ecoENERGY RETROFIT – HOMES

Objective

To assist homeowners and owners of existing low-rise properties make smart energy retrofit decisions that will result in significant energy savings and a cleaner environment.

Description

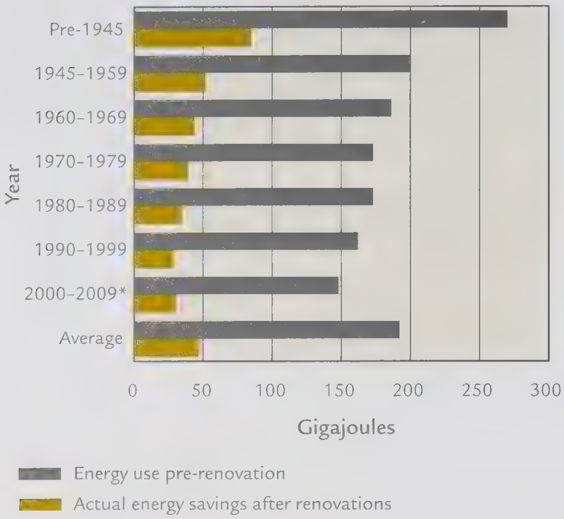
Initiated on April 1, 2007, the four-year, $745-million ecoENERGY Retrofit – Homes program provided federal grants to property owners for improving the energy efficiency of their homes and reducing their home's impact on the environment. Budget 2011 allocated an additional one-year investment of $400 million to the program.

ecoENERGY Retrofit – Homes offers a professional evaluation by a qualified energy advisor of the energy efficiency characteristics of a house, including a diagnostic test to determine air leakage. The energy advisor prepares a detailed personalized checklist of recommended upgrades for the property owner, including the EnerGuide pre-retrofit energy rating of the house. The checklist shows the recommended, most effective upgrades. The property owner chooses which upgrades to have done.

After the retrofit work is complete, the advisor performs a post-retrofit energy evaluation and

FIGURE 3-1

Residential Energy Use and Energy Savings per Household, Pre-1945 to 2000–2009



*Data for 2007 are from ecoENERGY Retrofit – Homes (previous data source was EnerGuide for Houses).

assigns a new energy-rating label. After the required improvements have been made, the property owner is entitled to a grant.

Figure 3-1 illustrates the energy use and savings gained per household before and after renovations.

Key 2010–2011 Achievements

- As of March 31, 2011, the ecoENERGY Retrofit – Homes program had received more than 510 000 grant applications from Canadian homeowners (surpassing the four-year program target of 460 000).
- The program has provided more than $700 million to more than 500 000 grant recipients. Participants reduced their annual energy consumption by about 20 percent and greenhouse gas (GHG) emissions by approximately three tonnes per house per year.
- More than 150 000 grants were paid for more energy-efficient renewable technologies and products, including water conservation equipment, wood burning appliances, ground-source heat pumps, solar domestic hot water systems and drain water treatment recovery pipes (representing 29 percent of program participants).
- All regions of Canada, except one territory, have full or partial matching programs from which homeowners can get seamless access to both federal and provincial/territorial government support for home retrofits.
- As of March 31, 2011, a reduction of approximately 1.75 megatonnes (Mt) of GHG emissions could be attributed to the ecoENERGY Retrofit – Homes program.

ecoENERGY RETROFIT – SMALL AND MEDIUM ORGANIZATIONS

Objective

To encourage building owners and managers of commercial and institutional buildings and industries to implement energy efficiency projects.

Description

Initiated on April 1, 2007, ecoENERGY Retrofit – Small and Medium Organizations, a $40-million program over four years, provided financial incentives to implement energy retrofit projects in buildings of less than 20 000 square metres and industrial facilities with fewer than 500 employees.

ecoENERGY Retrofit – Small and Medium Organizations provided up to 25 percent of the cost of a project, to a maximum of $50,000, based on estimated energy savings resulting from the project. Recipients of funding in this category could also qualify for funding support from utilities and/or other levels of government. To qualify, eligible organizations submitted an application detailing the energy efficiency project, including the total budget, timeframe for completion and expected results, based on a certified technical assessment of the building's or industry's energy use.

Key 2010–2011 Achievements

- As of March 31, 2011, 583 contribution agreements had been signed (244 buildings projects and 239 industry projects), bringing the

number of contribution agreements signed over the life of the program to 1 286 (710 buildings projects and 576 industry projects). In total, the agreements represent $287 million worth of projects, yielding annual energy cost savings of $45 million.

- More than 1 850 buildings and industry sector representatives took part in webinars and information sessions that provided program information.
- Over the course of the program, all of the approved projects will have led to a reduction in GHG emissions by an estimated 0.231 Mt.

ecoENERGY FOR BUILDINGS AND HOUSES

Objective

To encourage the construction and operation of more energy-efficient buildings and houses through a range of complementary activities, such as rating, labelling and training.

Description

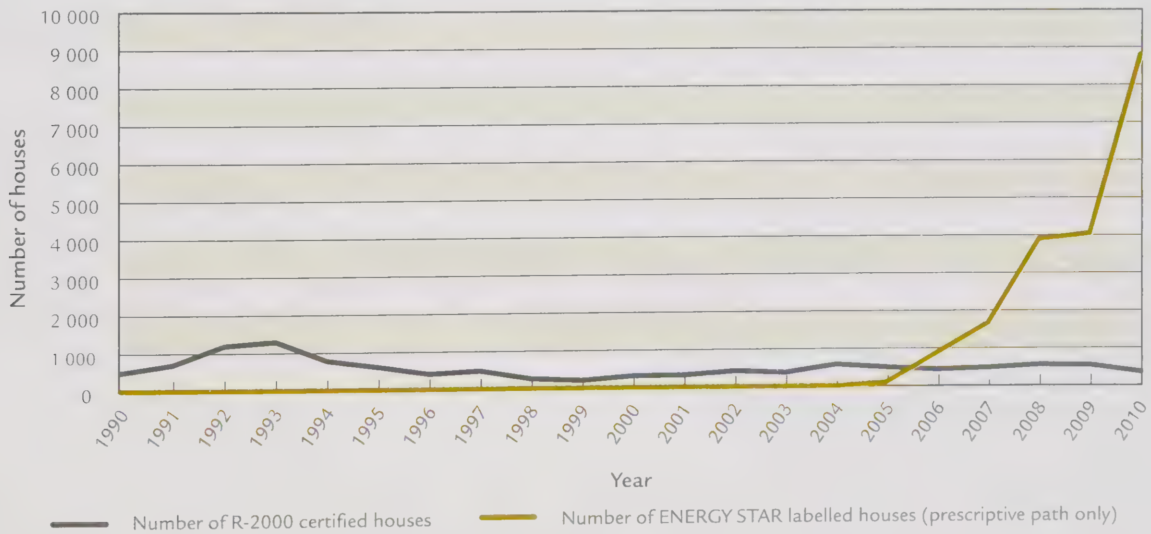
Initiated on April 1, 2007, the four-year, $60-million ecoENERGY for Buildings and Houses program included the following activities for the buildings sector:

- implementing new design tools and training, including building design simulation for new buildings and the Dollars to $ense Energy Management workshops for existing buildings, so designers, builders, owners and operators could learn about and use best practices and new technologies to improve the energy efficiency of new and existing buildings
- updating building energy ratings and promoting labelling systems for housing, including the EnerGuide Rating System (ERS), the R-2000 Standard[7] and ENERGY STAR® for New Homes, to encourage consumers to invest in energy-efficient upgrades during the construction planning phase of building a new home (see Figure 3-2)
- supporting the National Research Council financially to upgrade the *Model National Energy Code for Buildings*, now called the *National Energy Code for Buildings*, which was last published in 1997

[7] R-2000 is an official mark of Natural Resources Canada.

FIGURE 3-2

Number of R-2000 House Certifications and ENERGY STAR Prescriptive-Labelled Houses, 1990 to 2010



Source: NRCan national housing database and internal data.

- engaging in ongoing dialogue and co-operation with provincial and territorial programs to encourage other levels of government to adopt more stringent building energy codes
- providing training and implementing outreach and communication strategies to increase awareness and build capacity among builders, building owners, managers and consumers to support the adoption of sustainable energy efficiency programs
- establishing and maintaining partnerships to support initiatives aimed at reducing energy use and improving energy efficiency information

Key 2010–2011 Achievements

- By March 31, 2011, more than 1 580 building owners, managers, operators, designers and builders had received energy management training, while more than 350 commercial buildings received energy labels as part of a pilot program on energy management labelling and benchmarking.
- Issued more than 385 000 housing labels for new and existing houses.
- NRCan's EnerGuide Rating System (ERS) has been used in six provinces and territories (British Columbia, Manitoba, Ontario, Northwest Territories, Yukon and Nova Scotia) to develop or implement energy performance requirements in their building codes or municipal bylaws.
- As of the end of the 2010–2011 fiscal year, six provinces (British Columbia, Manitoba, Ontario, Quebec, New Brunswick and Nova Scotia) had announced changes to their building codes to achieve the ERS80 level by 2012. All provinces and territories participated in the Building Energy Codes Collaborative.
- In 2010–2011, a new Energy Code for Buildings was developed and approved. This code is 25 percent more stringent than the code published in 1997. It is designed to align with efforts deployed by other countries with similar climates; it exceeds the codes adopted by the U.S. states. The code was published in fall 2011.
- Since program inception, an estimated 1.49 Mt of GHG emissions have been saved as a result of the ecoENERGY for Buildings and Houses program.

For more information:
ecoaction.gc.ca/ecoenergy-ecoenergie/buildingshouses-batimentshabitations-eng.cfm

ecoENERGY FOR INDUSTRY

Objective

To improve industrial energy intensity and reduce energy-related industrial GHGs and air pollution.

Description

Initiated on April 1, 2007, the four-year, $18-million ecoENERGY for Industry program accelerated energy-saving investments and exchanged best-practices information within Canada's industrial sector. The program helped industry become more energy efficient by providing tools, training and cost-shared studies to enable industry to identify opportunities, calculate payback and overcome technical, management and financial barriers to energy efficiency project implementation.

The Canadian Industry Program for Energy Conservation (CIPEC) is an industry-government partnership delivered through the ecoENERGY for Industry program. The CIPEC network encompasses more than 50 associations and 25 industrial sectors, covering 98 percent of industrial energy use in Canada. Registered CIPEC Leader companies voluntarily commit to energy efficiency improvements as well as to reducing GHG emissions. Innovative companies at the leading edge receive recognition though the national CIPEC Leadership Awards.

Key program elements included the following:

- the Dollars to $ense Energy Management workshops, which taught industry members how to improve operational efficiency, generate energy savings and reduce GHG emissions

Natural Resources Canada

580 Booth Street
Ottawa, Ontario
K1A 0E4

Ressources naturelles Canada

580, rue Booth
Ottawa (Ontario)
K1A 0E4

July 16, 2012

Dear Sir or Madam:

Please find enclosed the publication *Improving Energy Performance in Canada, Report to Parliament Under the Energy Efficiency Act, 2010-2011.*

This report serves as a guide to Natural Resources Canada's policies and programs. It describes the progress being made to improve the energy efficiency in Canada's economic sectors and the contributions made by NRCan programs. It is produced annually.

This report is available at:
www.oee.nrcan.gc.ca/parliament10-11

If you would like to update your contact information, receive additional copies or be removed from the mailing list for this publication, please send an e-mail to euc.cec@nrcan.gc.ca.

Regards,

F. Campeau

France Campeau
Demand Policy and Analysis Division
Office of Energy Efficiency
Natural Resources Canada
E-mail: euc.cec@nrcan.gc.ca

Le 16 juillet 2012

Madame,
Monsieur,

Vous trouverez ci-joint un exemplaire de la publication intitulée *Améliorer le rendement énergétique au Canada – Rapport au Parlement en vertu de la Loi sur l'efficacité énergétique* pour l'année financière 2010-2011.

Ce rapport permet de trouver rapidement des renseignements généraux au sujet de Ressources naturelles Canada (RNCan) et de ses politiques et programmes. On y trouve un sommaire des progrès enregistrés dans les différents secteurs économiques du Canada en ce qui a trait à l'amélioration de l'efficacité énergétique, ainsi que la description des contributions faites dans le cadre des programmes de RNCan. RNCan produit ce rapport tous les ans.

Ce rapport est disponible à :
www.oee.rncan.gc.ca/parlement10-11

Si vous désirez mettre à jour votre liste de personnes-ressources, recevoir des exemplaires supplémentaires ou faire retirer votre nom de notre liste d'envoi pour cette publication, veuillez en faire la demande par courriel à euc.cec@rncan.gc.ca

Cordialement,

F. Campeau

France Campeau
Division de la politique et de l'analyse de la demande
Office de l'efficacité énergétique
Ressources naturelles Canada
Courriel : euc.cec@rncan.gc.ca

Canada

- ecoENERGY assessments for Industry, which offered a cost-shared solution to help industrial companies conduct state-of-the-art process integration and computational fluid dynamics studies that identify opportunities to increase energy efficiency and improve production processes
- the CIPEC Leaders network, which demonstrated industry sector commitment to reducing energy use, provided members with opportunities for networking, recognition and sharing of best practices, as well as eligibility for financial assistance
- tools, publications and benchmarking studies that created awareness of energy-saving opportunities and promoted actions to achieve those savings

DID YOU KNOW?

CIPEC was declared a Champion of Energy Efficiency by the American Council for an Energy-Efficient Economy (ACEEE) in 2009. CIPEC is the first organization outside the United States to win an ACEEE award. One of 56 nominees, CIPEC was recognized for demonstrating exceptional leadership in the development and implementation of energy efficiency initiatives for industry. More than 2 400 industrial facilities in Canada have joined the CIPEC network as CIPEC Leaders.

Key 2010–2011 Achievements

- More than 4 100 industrial energy managers have attended the Dollars to $ense Energy Management workshops since program inception, with almost 1 000 trained in 2010–2011. Customized workshops are held on-site to facilitate access in remote locations.
- Welcomed 208 new companies to the CIPEC Leaders network, which now has 2 400 registered companies. The total number of participant facilities in the program was 4 700 (nearly doubling the four-year program's target of 2 500).
- Almost 1 000 new subscribers received the *Heads Up CIPEC* electronic newsletter in 2010–2011.
- For a 2010–2011 impact analysis, 43 companies that had received financial assistance for a process integration study were interviewed. Collectively they implemented 55 percent of recommended projects, resulting in annual energy savings ranging from 10 percent to 25 percent, i.e. fuel energy savings of 6 600 terajoules/year ($54 million/year) and direct GHG reductions of 311 000 tonnes/year.
- Since program inception, the ecoENERGY for Industry program helped Canadian industry avoid approximately 1.54 Mt of GHG emissions.

For more information:
ecoaction.gc.ca/ecoenergy-ecoenergie/industry-industrie-eng.cfm

ecoENERGY FOR PERSONAL VEHICLES

Objective

To facilitate and support improvements in energy efficiency by encouraging Canadians to buy, drive and maintain their vehicles with fuel efficiency in mind.

Description

Initiated April 1, 2007, the four-year, $21-million ecoENERGY for Personal Vehicles program provided Canadians with information, tips and decision-making tools to assist them in changing their buying, driving and maintenance behaviours in order to reduce fuel consumption and GHG emissions from their personal vehicle use. It did so through the following:

- decision-making information and tools, such as the annual *Fuel Consumption Guide*, labels and vehicle awards
- Eco-driver curriculum and training
- fuel-efficient driving and tire inflation campaigns
- collaborative ventures with community groups and industry stakeholders

ecoENERGY for Personal Vehicles also provided the secretariat for, and managed the work with, the vehicle industry to implement and monitor the voluntary memorandum of understanding (MOU) between the Government of Canada and the Canadian auto industry to reduce automobile GHG emissions.

Program components included the following:

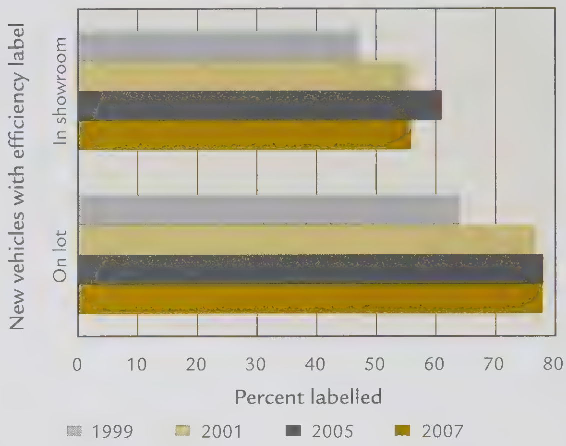
- the EnerGuide labelling system, which placed fuel consumption labels on all new light-duty vehicles sold in Canada (see Figure 3-3)
- the 2005 MOU between the Government of Canada and the Canadian auto industry – a framework for automakers to produce more fuel-efficient and lower-GHG-emission vehicles by 2010 (see Figure 3-4)
- the annual ecoENERGY for Vehicles Awards, which recognized and identified, for consumers, the most fuel-efficient light-duty vehicles in their classes available in Canada
- the Auto$mart driver education series, which taught drivers how to drive safely, save fuel and money, and protect the environment by using fuel-efficient driving techniques
- fuel-efficient driving and tire maintenance campaigns that used educational materials and outreach activities to encourage drivers to embrace fuel-efficient practices

Key 2010–2011 Achievements

- In fiscal year 2010–2011, more than 580 000 new drivers were exposed to the Auto$mart fuel-efficient driving curriculum, bringing the four-year total to more than 1.9 million (exceeding the program target of 500 000). A fuel savings of 5 percent to 25 percent is possible when drivers adopt fuel-efficient driving techniques.
- Since program inception, more than 1 200 000 copies of the *Fuel Consumption Guide* have been distributed. Also, the program collaborated with industry to promote and expand the distribution of fuel efficiency information in electronic formats.
- In 2010–2011, about 3.6 million Canadians were reached by targeted awareness campaigns, such as those for tire maintenance and fuel-efficient driving.
- Since program inception, a reduction of approximately 0.21 Mt of GHG emissions have been attributed to ecoENERGY for Personal Vehicles programming, and a reduction of 3.1 Mt to 3.4 Mt of GHG emissions has been attributed to the MOU with the Canadian auto industry.

FIGURE 3-3

New Vehicle Fuel Efficiency Labelling



Source: Corporate Research Associates, *2007 EnerGuide Label for Vehicles and Fuel Consumption Guide Audit Survey: Final Overall Report*, May 2007.

DID YOU KNOW?

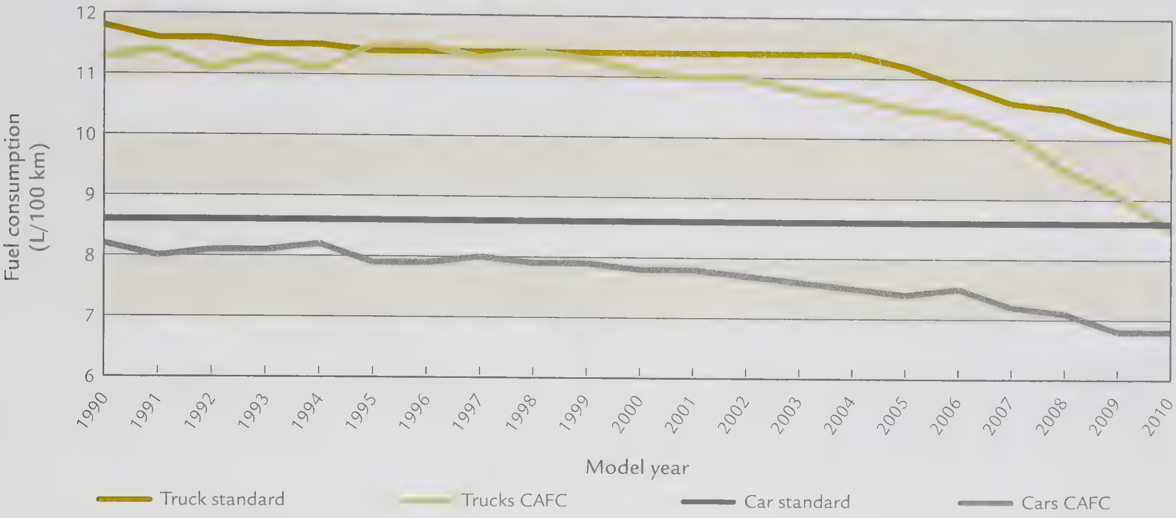
The 2010 *Fuel Consumption Guide* provides model-specific fuel consumption information to help Canadian motorists select the most fuel-efficient vehicle to meet their needs. It also provides information to help them drive and maintain their vehicles with fuel efficiency in mind.

For more information:

vehicles.nrcan.gc.ca

FIGURE 3-4

Company Average Fuel Consumption (CAFC) Versus Canadian Voluntary Standards, 1990 to 2010*



*2009 and 2010 data are estimates.

Source: www.tc.gc.ca/eng/programs/environment-fcp-cafctargets-385.htm

ecoENERGY FOR FLEETS

Objective

To achieve reductions in fuel use and related costs and GHG emissions through a wide range of measures targeting operators and managers of Canada's commercial and institutional road vehicle fleets.

Description

Initiated April 1, 2007, the four-year, $22-million ecoENERGY for Fleets program promoted the adoption of existing and emerging new technologies, such as energy-efficient vehicle components and hybrid technologies, and best practices, such as fuel management techniques. ecoENERGY for Fleets targeted the commercial/institutional fleet transportation sector and provided information, workshops, technical demonstrations and training programs on fuel-efficient practices for fleet vehicles.

Program components included the following:

- Fuel Management 101 workshops, which assisted fleet managers with the preparation, implementation and monitoring of a fuel management plan
- SmartDriver training programs, which offered knowledge sharing and on-the-road instruction to drivers of various types of fleets for the purpose of reducing fuel consumption
- funding for fuel-efficient technology demonstrations, which helped overcome knowledge barriers, encouraging uptake of fuel-saving technologies by fleets

Key 2010–2011 Achievements

- In fiscal year 2010–2011, more than 8 200 drivers were trained through the SmartDriver program, bringing the four-year total to nearly 23 000.
- More than 270 participants took part in Fuel Management 101 workshops to promote greater uptake of transportation energy efficiency practices, bringing the four-year total to nearly 800.
- Since program inception, a reduction of approximately 0.41 Mt of GHG emissions have been attributed to the ecoENERGY for Fleets program.

For more information:
fleetsmart.gc.ca

ecoENERGY FOR BIOFUELS

Objective

To support the production of renewable alternatives to gasoline and diesel and encourage the development of a competitive domestic renewable fuel industry.

Description

ecoENERGY for Biofuels provides an operating incentive to facilities that produce renewable alternatives to gasoline, such as ethanol, and renewable alternatives to diesel, such as biodiesel, based on production volumes. The program will invest up to $1.48 billion over nine years, starting April 1, 2008, in support of biofuel production in Canada.

This program is expected to increase domestic production and develop a competitive domestic renewable fuel industry. The expected program volume is 2.5 billion litres of domestic production by December 2012, with a target of 2 billion litres of renewable alternatives to gasoline and 500 million litres of renewable alternatives to diesel fuel.

In order to receive an incentive, eligible recipients must have signed a contribution agreement with NRCan and must have met the requirements of the *Canadian Environmental Assessment Act* and comply with all other applicable federal, provincial and municipal environmental legislation.

Key changes to the program were announced in December 2009: a realignment of the nine-year funding allocation, a new payment regime and new application and decision-making processes.

ecoENERGY for Biofuels is a key component of Canada's renewable fuel strategy, which aims to

- reduce the GHG emissions resulting from fuel use
- encourage greater production of biofuels
- accelerate the commercialization of new biofuel technologies
- provide new market opportunities for agricultural producers and rural communities

DID YOU KNOW?

Alternative fuels, such as ethanol, biodiesel and natural gas, have a lower carbon content relative to conventional fuels, such as gasoline and diesel. The increased production, awareness and use of alternative fuels can contribute to a reduction in GHGs in the Canadian transportation sector.

Key 2010–2011 Achievements

- As of March 31, 2011, 31 contribution agreements had been signed with companies. At least eight of these facilities are new and began production in 2010–2011.
- These agreements represent a total commitment of $1.133 billion and a domestic production of 2 973 million litres/year of biofuels (1 724 million litres of ethanol and 249 million litres of biodiesel by December 2012 but increasing thereafter to a maximum of 1 877 million litres of ethanol and 269 million litres of biodiesel).

For more information:
ecoaction.gc.ca/biofuels

FEDERAL BUILDINGS INITIATIVE

Objective

To assist Government of Canada organizations in implementing energy efficiency upgrades that lead to reduced energy and water use, GHG emissions and operating costs.

Description

The Federal Buildings Initiative (FBI) is a non-incented energy efficiency program for Canadian federal organizations (departments, agencies and Crown corporations) to help them undertake energy efficiency improvements.

The program provides tools, training, model documents (contracts, requests for proposals), program policy advice and procurement assistance to help federal organizations develop energy management plans and use energy performance contracting to finance energy efficiency retrofits of facilities.

Other levels of government, institutions and private sector firms have drawn on the FBI program experience for help in designing their own energy efficiency programs using energy performance contracting. Since its inception in 1991, the FBI has helped upgrade thousands of square metres of federal building floor space, saving $43 million in energy bills and reducing GHG emissions by approximately 285 kilotonnes per year.

DID YOU KNOW?

Using the innovative financing mechanism known as energy performance contracting, the FBI has led to the retrofit of one third of federal floor space without requiring new spending from taxpayers. More than $320 million of private sector funding, using energy performance contracting, helps to improve the energy performance of more than 7 000 buildings across Canada.

The FBI program celebrated 20 years of strong leadership in energy efficiency throughout the federal government in November 2011.

Key 2010–2011 Achievements

- Demonstrated leadership
  - On Oct. 6, 2010, the FBI's leadership was acknowledged when the FBI was identified as a best practice implementation strategy for departments to meet their GHG targets as required in the Federal Sustainable Development Strategy (FSDS) tabled in Parliament.
  - The FBI established the FBI Community of Practice (CoP) as a forum for federal energy managers, to ensure their access to other experts as they collectively discuss issues, strategies and tactics to improve energy efficiency. The CoP meetings have increased awareness of the program and have provided a networking opportunity among federal managers with similar objectives.
  - Increased awareness and exposure of the FBI has led to the FBI partnering with Public Works and Government Services Canada's Office of Greening Government Operations (OGGO) on government-wide awareness initiatives on meeting the FSDS targets. These initiatives are aimed at federal facility and environmental managers. The OGGO is responsible for environmental initiatives in buildings and for green procurement as per the FSDS strategy.
- Established a new financial and technical risk assessment mechanism for the FBI's qualified bidders list (QBL). The QBL pre-qualifies energy service companies based on their technical and financial capacity to undertake FBI projects within the federal fleet of buildings.

For more information:
oee.nrcan.gc.ca/fbi

NATIONAL RENEWABLE DIESEL DEMONSTRATION INITIATIVE

Objective

Initiated in December 2008, the National Renewable Diesel Demonstration Initiative (NRDDI) aimed to address remaining questions from industry and end-users about renewable diesel use by demonstrating how it will perform under Canadian conditions.

Description

The Government of Canada is committed to expanding the production and use of a range of cleaner, renewable biofuels, including renewable

diesel. The intent is to reduce GHG emissions that result from fuel use, encourage greater production of biofuels, accelerate the commercialization of new biofuel technologies and provide new market opportunities for agricultural producers and rural communities.

In December 2006, the government announced its intention to develop a regulation requiring an average annual 2 percent renewable fuel content in diesel fuel and heating oil by 2012, upon successful demonstration of renewable diesel fuel use under the range of Canadian conditions. In 2009, the government announced its intention to accomplish this by 2011, subject to technical feasibility. Technical feasibility was demonstrated, and the 2 percent regulation and the coming-into-force date for the requirement is July 1, 2011.

In consultations, Canadian industry sectors and end-users raised questions related to the proposed large-scale integration of renewable diesel into fuel distribution networks. The NRDDI aimed to address these remaining questions in advance of the proposed regulation coming into force.

Non-repayable contributions were provided to approved projects that demonstrated aspects of renewable diesel use and/or distribution in Canada.

Key 2010–2011 Achievements

- The NRDDI program consulted with 13 industry stakeholders to understand their technical questions about renewable diesel use in Canada. The NRDDI funded seven demonstration projects proposed by stakeholders to address their outstanding technical questions. Each project included a multi-stakeholder technical committee to ensure the project would address the needs of all stakeholders and the results would be presented in a scientifically sound manner. The NRDDI worked closely with Environment Canada and Agriculture and Agri-Food Canada to ensure that the results would also meet their needs. In addition, the NRDDI completed an infrastructure-readiness study to further inform the development and implementation of the proposed regulation.
- The NRDDI final report assessed the technical feasibility of the proposed regulation based on the results of the NRDDI and other relevant projects and studies. NRCan provided the final report to Environment Canada in October 2010, and the report was made public on NRCan's Web site in January 2011. Overall, stakeholders have indicated that their technical concerns have been addressed.

For more information:
oee.nrcan.gc.ca/transportation/alternative-fuels/programs/3330

CHAPTER 4 Clean Energy Science and Technology

INTRODUCTION

Natural Resources Canada (NRCan) invests in the research, development and demonstration (R,D&D) of new and emerging clean energy science and technology (S&T) that produces economic, social and environmental benefits for Canadians. NRCan's Office of Energy Research and Development (OERD) and CanmetENERGY lead the federal government's energy S&T operations.

The OERD oversees the management of the Program of Energy Research and Development (PERD), the ecoENERGY Technology Initiative (ecoETI) and the Clean Energy Fund (CEF). These programs allocated more than $239 million in the 2010–2011 fiscal year. The funds help find new, long-term, cleaner and more efficient solutions to reducing environmental emissions by developing and disseminating new knowledge and new technologies through R,D&D initiatives. In 2010–2011, more than 68 percent of the PERD program and activities allocated by the OERD were managed and carried out by NRCan (including CanmetENERGY), as were more than 97 percent of the ecoETI and CEF programs and activities allocated by the OERD. The six departmental priorities listed for CanmetENERGY (*see below*) also apply to the OERD.

CanmetENERGY generates and provides knowledge and technologies to advance the development and use of innovative solutions contributing to the well-being of Canadians and to progress toward meeting Canada's economic, social and environmental policy objectives. It works with industry, academia, utilities, associations, non-governmental organizations and other governments to develop and demonstrate energy-efficient, alternative transportation fuels, renewable energy technologies and cleaner fossil fuels.

CanmetENERGY undertakes projects and activities in the following areas of expertise:

- clean energy systems for buildings and communities
- clean electric power generation
- clean energy systems for industry
- clean transportation energy
- environmentally sustainable oil and gas development
- sustainable bioenergy

This chapter describes in detail the programs, activities and 2010–2011 key achievements of the OERD, CanmetENERGY and other partners in energy S&T.

For more information:

nrcan.gc.ca/eneene/science/resres-eng.php

canmetenergy.nrcan.gc.ca

PROGRAM OF ENERGY RESEARCH AND DEVELOPMENT

Objective

To fund research and development (R&D) designed to ensure a sustainable energy future for Canada in the best interests of its economy and the environment.

Description

PERD supports R&D activities within nine portfolios, comprising oil sands and offshore regulatory issues, sustainable bioenergy, the reduction of air impacts, the improvement of efficiency in electricity, the integration of alternative and renewable energy into the grid, and the improvement of efficiencies in end use, with a focus on transportation, buildings and industry. Efficiencies are sought in energy production, distribution and end use. Examples of funded projects appear throughout this chapter.

The portfolios are managed holistically and encompass the entire innovation spectrum – from basic research to applied research, pilot plants and demonstrations – ensuring faster deployment of technologies developed with federal funds.

The PERD budget for the 2010–2011 fiscal year was approximately $51.7 million. Of that amount, $16.3 million was allocated to 12 federal departments and agencies that are PERD partners, mostly to improve the science supporting Canadian regulations related to energy production and use. The remaining $35.4 million was allocated to energy R&D programs managed and performed in NRCan, more than 68 percent of which contributed to improved energy efficiency and the integration of renewable energy sources in Canada.

ecoENERGY TECHNOLOGY INITIATIVE

Objective

To support the development of next-generation energy technologies needed to break through to emissions-free fossil fuel production, as well as for producing energy from other clean sources, such as renewables and bioenergy, and to advance the development and use of new clean energy technologies in end-use sectors.

Description

The ecoETI is a component of ecoACTION, the Government of Canada's actions toward clean air and greenhouse gas (GHG) emissions reductions. It is a $230-million investment in clean energy S&T. The funding helps in the search for long-term solutions to reducing and eliminating air pollutants from energy production and use. Part of the funding has been allocated to the demonstration of carbon capture and storage. Eight projects have been selected in this area. Spending in the 2010–2011 fiscal year was nearly $72.7 million.

CLEAN ENERGY FUND

Objective

To fund the demonstration of technologies, including large-scale carbon capture and storage projects, and renewable energy and clean energy systems demonstrations to reduce GHG emissions and increase the percentage of electricity produced from clean sources.

Description

The $795-million CEF, a component of Canada's Economic Action Plan announced in 2009, provides funding for the demonstration of promising technologies to support the Government of Canada's commitments to reducing GHG emissions. Approximately 37 percent of the 2010–2011 CEF was committed to or earmarked for small-scale demonstration projects, including renewable and clean energy system projects and research related to marine energy, smart grid, wind, energy storage, bioenergy, geothermal energy in the North, and community energy systems.

The CEF expenditures for the 2010–2011 fiscal year were approximately $115 million. Of that amount, approximately $62 million was allocated to large-scale demonstration projects, and approximately $42 million was allocated to small-scale demonstration projects, which will contribute directly and indirectly to improved energy efficiency and the integration of renewable energy sources in Canada. Approximately $8 million was allocated to R&D.

Key 2010–2011 Achievements

- Thirteen demonstration-project contribution agreements in renewable energy and clean energy

technologies were signed in 2010–2011. These projects will demonstrate marine energy, smart grid, wind, energy storage, bioenergy, geothermal energy in the North, and community energy systems.

- Contribution agreements were signed for two of the three large-scale demonstration projects, bringing the Government of Canada commitment under contract to $150 million.

For more information:
nrcan.gc.ca/eneene/science/renren-eng.php

CLEAN ENERGY SYSTEMS FOR BUILDINGS AND COMMUNITIES

Objective

To develop, demonstrate and promote – in domestic and foreign markets – technologies, practical decision-making tools, processes, codes, standards and best practices that help communities select more efficient and cost-effective energy, waste and water technologies and design solutions to support a sustainable energy future based on reduced energy consumption and GHG emissions.

Description

CanmetENERGY plays a leadership role in the R,D&D of energy-efficient and renewable energy technologies for houses, buildings and communities by

- fostering the commercialization of new technologies
- identifying and developing opportunities for the integration of energy efficiency and renewable energy technologies
- developing infrastructure to support innovation, such as codes, policies and standards
- developing linkages between utilities, industry and academia
- supporting training and education
- disseminating results and findings
- facilitating the export of Canadian technologies to international markets
- engaging in international co-operation

Specific work includes the development of innovative technologies, particularly integrated systems, design, modelling and analysis tools and integrated design approaches, such as building energy simulation software, making it possible to achieve greater energy efficiency to be implemented at minimal incremental costs. CanmetENERGY develops, distributes and supports building energy simulation software for the Canadian construction industry and Government of Canada ecoACTION programs.

CanmetENERGY is active in conceiving, developing and optimizing energy-efficient space and water heating, ventilation, air-conditioning and refrigeration technologies, thermal storage systems and micro co-generation systems through, for example, standards development, energy efficiency labelling, heat recovery systems, combined heat and power and energy conversion and storage systems, integration of technologies and adaptation to the Canadian context.

CanmetENERGY assists in increasing the use of solar thermal and solar photovoltaic (PV) energy technologies in Canada by developing technologies, standards, policies and programs to create a Canadian-based, globally competitive solar industry. Other work includes community energy systems, daylighting, intelligent building control and operation systems, and the commissioning/recommissioning of buildings.

CanmetENERGY's partnerships with industry help to build advanced residential and commercial buildings that incorporate a wide array of innovative technologies and consume significantly less energy than their conventional counterparts. Under cost-sharing arrangements to accelerate the development and commercialization of a new generation of advanced and energy-efficient technologies, CanmetENERGY is helping the Canadian residential and commercial building industry produce some of

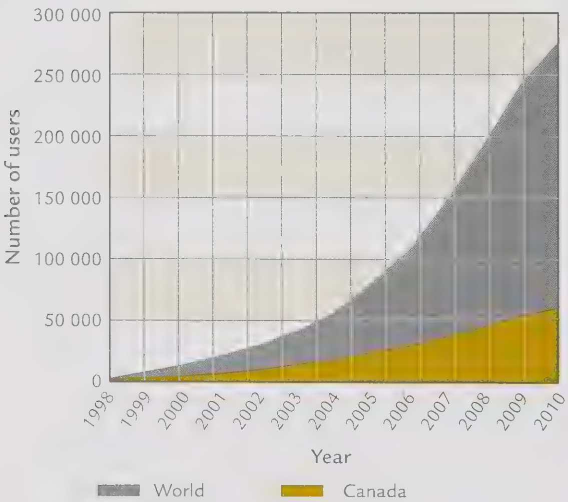
the most environmentally advanced structures on the planet.

Key 2010–2011 Achievements

- CanmetENERGY increased the number of users of the RETScreen®[8] Clean Energy Project Analysis Software to more than 276 000 people in 222 countries, adding an average of 1 000 new users every week (see Figure 4-1). More than 300 colleges and universities worldwide are now using RETScreen for education. As well, RETScreen was selected for several external awards, including the ENERGY GLOBE National Award for Canada, presented at the 2010 World Environment Day hosted in Kigali, Rwanda; the Government Technology Exhibition and Conference (GTEC) Distinction Award Medal (National Category) for International Partnerships; and a Public Service Award of Excellence (Innovation category) for demonstrating leadership and commitment and helping to build Canada's international reputation as a serious player in enabling clean energy worldwide.

FIGURE 4-1

RETScreen Software: Cumulative Growth of User Base



Source: NRCan/RETScreen Customer Database.

- The DABO™ software developed by CanmetENERGY helps to reduce significantly building energy consumption by optimizing the operation of mechanical systems for heating, cooling and ventilation. DABO is a fault detection and diagnosis, performance analysis and documented history creation software application. This continuous building optimization program adds intelligence and memory to the building automation system. IFCS, a Montréal-based company specialized in software editing, is the commercial partner for distributing DABO in Canada, Europe and China. In 2010–2011, IFCS signed DABO licences with Centre universitaire de santé McGill, Banque Nationale du Canada headquarters in Montréal, Université du Québec à Montréal, and Veolia Environnement, a multinational company based in France.
- A field trial of an advanced zoned heating and cooling system, recently completed over three years in 25 homes across Ontario, has demonstrated substantial energy savings and improved homeowner comfort. On the comfort side, the system heated basements more effectively in winter and resulted in cooler and less humid upper levels during hot summer days and nights. On the energy efficiency side, the system demonstrated a 7 percent reduction in annual gas use, a 15 percent reduction in annual electrical use and up to 30 percent summer-peak electrical savings versus baseline high-efficiency non-zoned furnace systems. Results of this work, one of 40 demonstrations, have formed the basis for the Local Energy Efficiency Partnership (LEEP™) presentation series on zoned heating and cooling systems. The Heating, Refrigeration and Air Conditioning Institute is also working with its membership to further advance the technology.

For more information:

canmetenergy.nrcan.gc.ca/eng/buildings_communities.html

[8] RETScreen is a registered trademark of Her Majesty the Queen in Right of Canada as represented by the Minister of Natural Resources

CLEAN ELECTRIC POWER GENERATION

Objective

To develop and apply technologies for renewable electricity production and for cleaner power generation from fossil fuels, with the goal of increasing efficiency and achieving the reduction and, ultimately, the elimination of emissions of acid rain precursors, GHGs, particulates and identified priority substances, such as mercury, trace elements and organic compounds.

Description

CanmetENERGY's work on clean electric power generation focuses on improving the economics and efficiency of renewable energy technologies, including wind energy, solar power, small and low-head hydro, marine energy and energy storage.

CanmetENERGY's S&T supports the growth of the renewable energy industry in Canada by:

- fostering the development of new technologies
- identifying and developing opportunities for building a "smart" power grid of renewable energy
- developing infrastructure to support innovation, such as codes, policies and standards
- developing linkages between utilities, industry and academia
- conducting nationwide resource assessments and mapping

CanmetENERGY also focuses on improving the performance of, and reducing emissions from, existing fossil fuel power plants. Moreover, it focuses on developing new advanced cycles for the conversion of fossil fuels to electricity with complete or near-complete capture and elimination of carbon dioxide (CO_2) and other emissions. Additional research includes work on issues associated with the transport and storage of CO_2. Through advanced tools and technologies, CanmetENERGY assists major industrial energy consumers in reducing the energy intensity of their operations and in reducing GHG emissions and emissions of other air pollutants, while enhancing competitiveness and profitability.

CanmetENERGY's work on emerging technologies in clean power includes new forms of power generation, such as wind, solar photovoltaics, small hydro, marine, natural gas combined-cycle plants and advanced fluidized bed combustion. Significant R&D also focuses on CO_2-neutral combustion systems, CO_2 sequestration, CO_2 injection for enhanced oil recovery, advanced power generation cycles, clean coal technologies and distributed energy resources. CanmetENERGY also conducts leading-edge work in the burgeoning priority area of decentralized energy resources, where renewable energy sources are becoming more localized and integrated into the main power grid.

CanmetENERGY:

- addresses the technical, institutional and regulatory barriers to clean power by promoting power grid integration, developing standards, generating knowledge and transferring important information to Canadian decision-makers
- provides stakeholders with the necessary information to make informed decisions, and coordinates various research projects
- participates in international committees that establish standards and codes
- develops and hosts workshops and conferences
- develops publications and produces training tools
- capitalizes on its sector expertise by carrying out projects in collaboration with key research consortia, including industry, universities, research groups, public services and other departments and governments

DID YOU KNOW?

A major obstacle to solar technology deployment is seasonal availability of the resource. NRCan researchers are introducing new approaches and systems integration to demonstrate the viability of solar thermal energy storage in Canada that can meet up to 90 percent of space heating needs in Canadian homes.

Key 2010–2011 Achievements

- CanmetENERGY provided technical and financial support to the development of the Very Low Head (VLH™) hydro turbine technology, which was successfully demonstrated in France. CanmetENERGY also worked with the Coastal HydroPower Corporation (British Columbia) in conducting a cold-climate adaptation engineering study. Additionally, work was conducted on the development of a cold-climate adaptation package that integrates solutions for Canadian VLH™ site deployments. Now CanmetENERGY is working with Carleton University and Fisheries and Oceans Canada to determine the fish-friendliness of the VLH™ turbine for typical Canadian river systems. Having identified potential demonstration sites and partners in Alberta and Ontario, CanmetENERGY is firming up projects.
- CanmetENERGY is a co-chair of the national Smart Grid Technology and Standards Task Force that aims to identify the current status and future needs of the electric power industry. The task force reports to the Canadian National Committee of the International Electrotechnical Commission and the Standards Council of Canada. CanmetENERGY provides technical expertise to assess the needs in advanced electricity meters and the interoperability of equipment interconnected to the grid. The recommended standards will serve as the basis for a renewed effort to identify key requirements for deploying a modern and resilient electricity transmission and distribution infrastructure in Canada.
- With technical and financial support from CanmetENERGY and Saskatchewan Research Council of Regina, Advanced Engine Technology Ltd. of Ottawa implemented a very successful field trial demonstration of a 6-kWe micro-cogeneration unit at Inland Metal in Regina. Through detailed monitoring and optimization, the unit has operated for more than 4 200 hours, enabling efficiency improvements ranging from 77 percent to 87 percent. This will allow improved units, targeted for installation in Saskatchewan.
- Integrated high-efficiency heating appliances using thermophotovoltaic and thermoelectric generation technologies were developed and prototyped. In these appliances, a portion of fuel combustion heat is converted to electricity while meeting the heating needs for homes. The thermophotovoltaics/thermoelectric power generation is applied to new and existing boilers to generate electricity and produce heat and domestic hot water. The value of the integrated energy systems, provided to the consumer, is in the reliability of the heating system and the reduction of electric power consumption.
- CanmetENERGY, in collaboration with Defence Research and Development Canada (DRDC), Advanced Engine Technology Ltd. and Saskatchewan Research Council, undertook a project to seek innovative integration strategies for sea-water heat pumps driven by on-site cogeneration units. Many northern communities and military installations are challenged by the harsh environment and lack of indigenous energy sources and have few options for a green energy future. Solar and wind resources are seasonal, highly variable and adversely affected by the severe climate. In most cases, every litre of diesel fuel must be delivered by ground, barge or aircraft to such sites. Canadian Forces Station Alert, a community at the northernmost tip of Ellesmere Island, is the site chosen for this work. DRDC is particularly interested in evaluating the long-term sustainable energy options for such communities.

The goal is to dramatically lower the energy-related footprint of the community at Alert.

For more information:
canmetenergy.nrcan.gc.ca/eng/clean_fossils_fuels.html
canmetenergy.nrcan.gc.ca/eng/renewables.html

CLEAN ENERGY SYSTEMS FOR INDUSTRY

Objective

To identify, encourage and support the development and application of leading-edge, energy-efficient and environmentally responsible processes, practices, products, systems and equipment in Canadian industry to improve its energy efficiency, productivity, competitiveness and profitability, while reducing GHG emissions and other environmental impacts.

Description

CanmetENERGY works with industry to co-manage and share the costs of development and commercialization of a range of technologies, including process integration, learning-based expert systems, combustion systems and controls, manufacturing processes, and environmentally friendly and energy-efficient processes for energy-intensive industries. CanmetENERGY's S&T in the industry sector focuses on plant-wide industrial process analysis techniques and advanced process control systems that identify and correct inefficiencies in plant operation and design while taking into account energy, economic and environmental aspects.

CanmetENERGY's S&T also includes the development and testing of semi-pilot-scale plants, pilot plants, prototypes and full-scale field trials. This research evaluates operating performance, energy efficiency and environmental impacts and emerging concepts in chemical and energy conversion, including hydrogen production from hydrocarbon and renewable sources. In addition, CanmetENERGY disseminates technical information to encourage adoption of these techniques and practices in targeted energy intensive sectors of Canadian industry.

CanmetENERGY clients are from a variety of industries, including pulp and paper, gas, oil upgrading and refining, petrochemicals, engine manufacturing, steel, chemicals, food and drink, solid wood, waste oil recycling and rendering, and specialty ceramic manufacturing. Its other clients are gas and electric utilities, equipment manufacturers and other governments.

Key 2010–2011 Achievements

- CanmetENERGY signed an agreement with VERI, the research centre of Veolia Environnement to develop and test an ejector-based system prototype to recover waste heat for cooling applications. The ejector system is an innovative thermal compressor developed at CanmetENERGY that aims to improve cooling, heating and refrigeration applications.
- In collaboration with l'Agence de l'efficacité énergétique in Quebec, CanmetENERGY delivered four three-day seminars on process integration and trained 60 professionals and decision-makers from engineering firms, consultants, utilities and industries to better analyse heat recovery projects within industrial facilities. The seminars focused on the use of a site-wide approach that considers process units and utility systems as a whole, to maximize energy savings. Participants had the opportunity to solve case studies using the *Integration* software tool developed by CanmetENERGY. With *Integration*, a powerful tool with unique capabilities, users can identify and evaluate the impact of heat recovery projects and operational improvements in small and medium-sized enterprises and in large industries. These activities are part of a multi-year capacity-building program aimed at improving industrial energy efficiency in Quebec.
- CanmetENERGY worked collaboratively with La Boîte à science, a company specializing in tools and activities designed to raise student awareness of science and technology, in developing a

teacher's kit on energy use and conservation for high-school classrooms. "2025: L'Odyssée de l'énergie" consists of a team game through which pupils discover the principles of heating and cooling and are introduced to the notion of heat recovery. Players are then faced with the task of reducing energy consumption in simplified versions of typical industries, such as paper mills and food-processing plants. The kit was launched at the annual conference of the Association pour l'enseignement de la science et de la technologie au Québec, where it was very well received. To date, 21 schools from all regions of Quebec have reserved the kit, and the Canada Science and Technology Museum in Ottawa has expressed interest in this unique product.

For more information:
canmetenergy.nrcan.gc.ca/eng/industrial_processes.html

ENVIRONMENTALLY SUSTAINABLE OIL AND GAS

Objective

To provide S&T for the continued, secure supply of affordable, cleaner and more efficient fossil fuels, with little or no adverse environmental impact on GHG and Criteria Air Contaminant (CAC) emissions, and thereby help resolve oil sands environmental issues (including water) and clean air issues for the upstream oil and gas industry.

Description

CanmetENERGY conducts fundamental and applied research to develop knowledge and implement leading-edge technologies for the oil sands sector. Knowledge gained is used to inform energy policy development and industry decisions that will improve the quality of life for Canadians.

CanmetENERGY fosters innovation in oil sands and heavy oil technology through activities ranging from fundamental science to commercial-scale technical support. CanmetENERGY's strength lies in its staff's fundamental understanding of the chemistry, physics and engineering of oil sands and heavy oil processes, coupled with sophisticated analytical instrumentation and pilot-scale units providing proof of concept for technologies.

S&T is a key tool used by NRCan to make significant progress toward meeting its water and tailings, GHG and other air emissions challenges in the oil and gas sector. Major improvements need to be made in the entire process chain of oil sands and heavy oil development, from the initial extraction to the production of petroleum products.

CanmetENERGY's international client base and partnerships with provincial and territorial governments, industry and academia ensure that the best available technologies in the world can be applied to the resource. Its partnerships also ensure there are strong synergies and fast-track deployment of new technologies, innovations and knowledge dissemination.

Key 2010–2011 Achievements

- CanmetENERGY was selected as the lead of the technical program for a new tailings consortium's field demonstration of two dry stackable tailings technologies. The consortium includes Syncrude Canada Ltd., Shell Canada, Canadian Resources Ltd., and TOTAL E&P Canada. Following the success of the project's technology sharing, an industry-wide collaboration on tailings was formed and announced in 2010. As the lead of the technical program, CanmetENERGY ran a commercial scale demonstration of the centrifuge program in the summer of 2011.
- CanmetENERGY has developed new analytical methods, one of which was published in the scientific literature, to study the movement of naphthenic acids and process chemicals between the process water and solids. These methods use relatively accessible instrumentation that other researchers in this field can use to analyse this important family of oil sand process water contaminants.

- CanmetENERGY has collaborated with Carleton University and the National Research Council to successfully develop and field test a novel camera-based technology known as Sky-LOSA (Line of Sight Attenuation), which enables quantification of soot particle mass emission rates from a distance. This set-up is the first demonstration of a soot emission measurement with Sky-LOSA under field conditions. Additionally, it is the first time the soot emission rate in the unconfined atmospheric plume of a flare has been directly quantified. In collaboration with the World Bank's Global Gas Flaring Reduction (GGFR) partnership and the Global Methane Initiative, this Canadian technology will be field tested in Mexico and China. This initiative is a part of Canada's efforts to assist these jurisdictions in quantifying and reducing emissions associated with oil and natural gas production.
- CanmetENERGY and the U.S. Department of Energy's (DOE's) Vehicle Technologies Program consulted energy companies to solicit input from knowledgeable individuals that could be used to increase the efficiency of government-sponsored fuels and engine research in achieving its intended purpose. A preliminary release noted that all national laboratory research on fuels characterization and CanmetENERGY Devon's work on heavier fuels in particular were significant. Areas identified for continuing research included molecular structure of fuels, combustion kinetics, engine modelling and federal laboratory participation in standards' organizations and energy-vehicle joint research programs. Advice also included the call for more work on life cycle analysis and a recommendation that national laboratories spend more effort on educating the public and politicians on fuels and combustion issues.
- CanmetENERGY is performing research in such areas as the blending and co-processing of biomass- and bitumen-derived feeds. Researchers have developed characterization and analytical methods for co-processing these feeds and products and have developed methods and procedures to address the observed incompatibility of bitumen- and biomass-derived feedstocks. CanmetENERGY has also completed a collaborative bio-gasoline project with Suncor Energy Products Inc. to expand petroleum-cracking technology through the addition of biomass components. CanmetENERGY's research led to the commercialization of bio-gasoline technology and was acknowledged by Suncor management.

DID YOU KNOW?

CanmetENERGY Devon's research results have supported the development of science-based clean air regulation domestically and have been incorporated into international codes of practice for such organizations as the World Bank's GGFR partnership and the international Global Methane Initiative and Asia-Pacific Partnership on Clean Development and Climate.

For more information:
canmetenergy.nrcan.gc.ca/eng/clean_fossils_fuels.html

CLEAN TRANSPORTATION ENERGY

Objective

To develop and deploy, in partnership with industry, academia and the provinces and territories, leading-edge hydrogen, fuel cell and transportation energy technologies that reduce GHG emissions and minimize urban air pollution.

Description

CanmetENERGY works with stakeholders in domestic and international hydrogen and transportation industries. These industries include original equipment manufacturers, industry associations, fleet managers, transit authorities, utilities, provincial and territorial governments, research organizations, universities, other federal departments, the U.S. DOE, the International Energy Agency (IEA) and the International Partnership for the Hydrogen Economy.

Together, in these partnerships, projects are well leveraged – typically at a 50:50 ratio.

Transportation research, development and deployment activities at CanmetENERGY are grouped into three principal technology areas: hydrogen and fuel cells, hybrid and electric vehicles, and advanced fuels and technologies. All three technology areas are highly involved in domestic and international outreach and in safety, codes and standards for technology adaption and integration.

Since the early 1980s, CanmetENERGY's partnerships with industry have been playing a significant role in establishing Canada as a world leader in fuel cell and hydrogen-refuelling technologies.

Today near-term accomplishments are being made in the transportation and materials handling sectors. R&D in production, storage and utilization continue to lower costs and improve the performance of the hydrogen technologies.

Hydrogen fuelling stations and hydrogen-powered forklifts, airport baggage-tuggers, personal vehicles and shuttle buses continue to be deployed across Canada. In addition to vehicles and fuelling stations, developments in waste hydrogen capture and purification, production, distribution and storage are building the hydrogen infrastructure.

As well, applications in markets outside the transportation sector are being realized, such as micro fuel cells / portable applications (e.g. laptops and cellular phones) and stationary applications (e.g. off-grid and backup power for computers and buildings).

Electricity as an alternative transportation fuel is also becoming a near-term reality for Canada. Hybrid and electric vehicle technologies offer energy-saving advantages over current vehicle technologies that run solely on conventional fuels, such as gasoline or diesel.

CanmetENERGY is involved in R&D of on-board energy-storage and power systems, such as batteries and fuel cells. As the Government of Canada's lead, CanmetENERGY plays a significant role in coordinating and reviewing technical input from many private and public partners for the Canadian Electric Vehicle Technology Roadmap (evTRM).

Advanced fuels and technologies encompass all fuels and technologies in addition to hydrogen and fuel cells and hybrid and electric vehicles – examples are biodiesel, natural gas and ethanol. CanmetENERGY supports R&D for testing advanced fuels and fuel usage, as well as engine performance and components.

This area of R&D is serving to strengthen a Canadian industry that is now exporting commercial products. International collaborative efforts are helping to leverage Canada's research funding – particularly for the evaluation of fuels and hardware performance and in developing standards.

DID YOU KNOW?

By 2018, there will be at least 500 000 highway-capable plug-in hybrid electric-drive vehicles on Canadian roads, as well as what may be a larger number of hybrid-electric vehicles. All these vehicles will have more Canadian content in parts and manufacture than vehicles on the road in Canada in 2008.

Key 2010–2011 Achievements

Research and Development

- CanmetENERGY partnered with Hydrogenics Corporation of Mississauga, Ontario, to make major improvements in hydrogen production from proton exchange membrane (PEM) water electrolysis technology. These improvements included the continuous operation of the PEM water electrolyzer for 22 000 hours with no failure and no performance loss. The electrolyzer demonstrated an energy efficiency of 75 percent, which exceeds the U.S. DOE target for 2017. Rapid dynamic response and cycling capability was also conducted using a simulated photovoltaic solar plant input, indicating the

technology's viability for renewable energy applications.

- Canadian-based Ballard Power Systems Inc. is a world leader in the development, manufacture, sale and servicing of clean-energy hydrogen fuel cells. In 2010–2011, with support from CanmetENERGY, Ballard improved its understanding of the effect of antioxidant additives in the membrane electrode assembly on fuel-cell durability. These antioxidant additive test results, together with fuel-cell stack shut-down/start-up test data, have been used to develop and refine an empirical stack model that predicts performance degradation. This model enables the setting of improved product warranty targets, leading to improved marketability.
- Solid oxide fuel cells are highly efficient, non-polluting energy devices. However, the high operating temperatures usually required for these fuel cells put severe restrictions on their life and reliability. The Hydrogen and Fuel Cells laboratory at NRCan is investigating new solid oxide fuel cell materials that can operate at reduced temperatures and alleviate these issues. Anode-supported button-type fuel cells were prepared and tested. Results indicate that anode-supported fuel cells could operate at lower temperatures.
- CanmetENERGY partnered with the Canadian Standards Association (CSA) on the development of Technical Information Letters to bridge the gap between the introduction of electric vehicles and the development of codes and standards for their use. Work continues with CSA on developing and harmonizing codes and standards for electric vehicles.
- CanmetENERGY and Electrovaya Inc., a major battery manufacturer in Canada, worked to improve the design and process for manufacturing advanced batteries for electric vehicles. Activities focused on the design and commissioning of a custom furnace for a molten salt process for producing tin-encapsulated carbon nanotube anode material and on a new low-temperature cell using a new electrode design that shows improved low-temperature performance.

For more information:
canmetenergy.nrcan.gc.ca/eng/transportation.html

SUSTAINABLE BIOENERGY

Objective

To assist Canadian industry in the R,D&D of bioenergy technologies, thereby increasing the production and use of bioenergy, which generates environmental and economic benefits.

Description

CanmetENERGY supports the R,D&D of bioenergy technology through cost-shared agreements, promotes bioenergy as a renewable and sustainable energy source, advocates the need for proper policies and programs relating to bioenergy, and raises the public's and policy-makers' awareness of the benefits of bioenergy.

CanmetENERGY's biomass energy conversion technology expertise covers the following main processes:

- combustion – converting forestry, agricultural and municipal residues into heat and power under environmentally sound conditions
- gasification – converting forestry, agricultural and municipal residues into syngas
- pyrolysis – converting forestry and agricultural residues into bio-oils and value-added products
- fermentation – converting the starch and cellulose components in biomass into bio-ethanol
- transesterification – converting a variety of new and used vegetable oils, tallow and yellow grease into bio-diesel
- anaerobic digestion – converting manures and food-processing and municipal wastes into methane-rich biogas

Activities focus on improving the reliability and lowering the cost of technologies, disseminating information on technology feasibility and economics

to potential users, and helping industry demonstrate its products in domestic and foreign markets.

Initiatives include R,D&D, technical and socio-economic studies, end-use demonstrations and testing, feasibility studies, process analysis, verification, testing and improvement, standards development, emissions reductions, modelling, conference and workshop support, information dissemination, IEA collaboration and committees, stakeholder education, and standards development.

NRCan plays a leadership role in the Canadian Biomass Innovation Network (CBIN), a multidepartmental working group formed to direct federal R&D on bioenergy and bioproducts. Clients include the agricultural and forestry sectors (biomass producers and bioenergy consumers), municipalities and industrial partners.

The CBIN supports strategic R&D in bioenergy, biofuels, bioproducts and industrial bioprocesses to reduce fossil-fuel energy consumption, directly or indirectly reduce GHG and CAC emissions, diversify energy supply and seed the development of Canada's bio-based economy.

CBIN is a horizontal program developed and managed by five departments and one agency: Agriculture and Agri-Food Canada, Environment Canada, Industry Canada, National Research Council Canada, NRCan and the Natural Sciences and Engineering Research Council of Canada. CBIN coordinates and manages three federal government bio-based R&D initiatives, including the following:

- Program of Energy Research and Development – Bio-Based Energy Systems and Technologies Program ($3.0 million in 2010–2011)
- ecoENERGY Technology Initiative – Bio-Based Energy Systems ($1.7 million in 2010–2011)
- Clean Energy Fund R&D Initiative ($0.9 million in 2010–2011)

Key 2010–2011 Achievements

- CanmetENERGY, in collaboration with the Wood Pellet Association of Canada, has made significant contributions to writing and editing *The Pellet Handbook*. This first comprehensive guide in English covers all aspects of pellet production and utilisation. Published in fall 2010, the handbook is the result of collective efforts of the members of the IEA Bioenergy Implementing Agreement.
- CanmetENERGY has acted as a technical advisor to the Cement 2020 project and contributed to Lafarge's biomass-combustion test trials. The Cement 2020 project builds on the Energy Farm project of 2008, whereby various non-food energy crops were planted on land at Lafarge's Bath Cement Plant and on neighbouring lands and then subjected to scientific and practical study for their possible role as fuel for the cement industry. The objective of Cement 2020 is broader: to evaluate the technical, environmental and social implications of replacing fossil fuels in the manufacture of cement. The results of the biomass combustion tests were so encouraging that the plant could completely cut its use of fossil fuels by the end of the decade. In the short-to medium-term, to meet the goal of 30 percent replacement at the Bath plant, Lafarge is looking to source up to 50 000 tonnes of cleaner fuel. Eventually, the experience gained at the Bath plant will be the base for a standard set of guidelines for implementing cleaner, greener fuels by the cement industry worldwide.
- CanmetENERGY is working with a consortium, led by Manitoba Hydro, on the Bioenergy Optimization Program. As one initiative under this technology development program, Ensyn demonstrated, on a commercial scale, the viability and ease with which bio-oil can be fired in various industrial boilers across Manitoba. To facilitate broad testing, a portable fuel-delivery system that addresses the specific requirements of bio-oil handling was designed and built. The test program demonstrated that bio-oil could replace wood waste, waste oil and bunker C fuel oil in a boiler used to produce steam for papermaking. As a result of this successful test program, Tolko Industries Ltd. announced in 2010 that it will install a 400-tonnes/day Ensyn rapid thermal

processing (RTP) unit at its forest operations in High Level, Alberta. This unit could produce 85 million litres of pyrolysis oil per year.

- As a result of CanmetENERGY work, pyrolysis has been identified as one of the priorities under the U.S.-Canada Clean Energy Dialogue. Co-operation in the pyrolysis field was one of three topics at the Canada-U.S. meeting held at the National Renewable Energy Laboratory in Golden, Colorado, in March 2010. As a result of discussions between the two countries, a project was approved to receive $50,000 for collaborative work in pyrolysis. To increase the scope of this collaboration, an additional $58,000 was provided under the Security and Prosperity Partnership of North America. CanmetENERGY has worked with the U.S. DOE Pacific Northwest National Laboratory (PNNL) to develop a work plan to perform comparative tests on some biomass feedstocks that it will prepare and ship to PNNL.

- The Nexterra Systems Corp. gasification system at the New Westminster, British Columbia, Kruger Products installation is the first commercial demonstration of the company's direct-fired gasification system and a first of its kind in the pulp and paper industry. The Kruger installation won the Best New Technology Application award in June 2010, with the British Columbia Technology Industry Association acknowledging the use of technology to enhance overall productivity and business operations. Since the installation of the new gasification system, Kruger has achieved significant energy cost savings, even at current low natural gas prices, and is considering adding a third gasifier to increase boiler capacity. In aggregate, currently installed Nexterra systems could displace more than 2 million British thermal units per year of fossil fuels (equivalent to heating 770 000 North American homes) and reducing GHGs by more than 100 000 tonnes per year (equivalent to taking 25 000 cars off the road). According to Nexterra, "Support from NRCan is one of the key reasons the company has been able to grow into a world leader in bioenergy."

- A new third-generation bio-baler developed in 2009 with NRCan by Agriculture and Agri-Food Canada is being sold commercially under licence by the Anderson Group in Chesterville, Quebec. The Anderson Group sold 21 units between November 5, 2009, and April 22, 2011, generating $1.6 million in revenue. The bio-baler has been nominated by the American Society of Agricultural and Biological Engineers for an AE50 award in 2011 (the bio-baler was identified in the top 5 of the top 50 innovations in agriculture and bio-resource engineering). The machine has been recognized in the British House of Lords as a part of exciting technology used in the United Kingdom for bioenergy.

- NRCan and Agriculture and Agri-Food Canada contributed to the development of the Biomass Inventory and Mapping Analysis Tool (BIMAT). The BIMAT was initiated under the former Technology & Innovation R&D Initiative and received further funding under ecoETI and PERD. The BIMAT, available on the Internet, allows users to calculate the amount of available biomass in a given geographic area of Canada. This information is having application in developing policy and regulations and identifying where to locate bioenergy facilities. Canada is demonstrating global leadership in the development of such tools, as evidenced by the growing demand for developers as invited speakers throughout the world. In 2010–2011, the BIMAT was expanded to include 1) wood residues or dedicated biomass crop to ownership/management responsibility, 2) juvenile hardwood natural forest stands, 3) supply-chain indices for both residues and purpose grown biomass opportunities that allow users to assess economics of biomass supply, and 4) economic and carbon cost model functions for transportation logistics. In 2010, the Web site had more than 2 600 visits and performed more than 600 calculations.

- Established the first two production test sites for fast-growing selected clonal aspen in Alberta, the result of 15–20 years of work by a consortium of forest industry partners. Experience to date shows that aspen managed appropriately can yield higher volumes with higher value fibre attributes than other species used in short-rotation scenarios and is well adapted to the harsh weather conditions of the Prairies.

DID YOU KNOW?

The IEA identifies cost as the principal obstacle to widespread deployment of carbon capture and storage (CCS). NRCan researchers are testing a novel technology to clean and liquefy CO_2 for injection in deep rock formations. This technology uses no chemicals and promises to reduce the cost of CCS.

For more information:

canmetenergy.nrcan.gc.ca/eng/bioenergy.html

cbin.gc.ca

CHAPTER 5 Renewable Energy

RENEWABLE ENERGY USE

In 2009, renewable sources accounted for approximately 64.5 percent of Canadian electricity generation and 61.8 percent of total electricity-generating capacity (see Table 5-1). Most of the renewable energy used in Canada comes from either hydroelectricity or thermal energy from biomass, such as wood-waste sources, although the contribution of wind power and solar photovoltaic, the fastest growing sources of electricity in Canada, is becoming increasingly important in the national energy mix (see Table 5-2).

TABLE 5-1

Electricity-Generating Capacity From Renewable Sources (Includes Hydroelectricity)

Year	Renewable electricity generation capacity (megawatts)	Total capacity (percent)	Percent change
1990	59 557	58.0	–
1991	61 116	58.0	3.0
1992	62 895	58.0	2.9
1993	63 114	56.0	0.3
1994	63 175	56.0	0.1
1995	66 542	57.0	5.3
1996	67 101	59.0	0.8
1997	68 202	61.0	1.6
1998	68 340	62.0	0.2
1999	68 614	61.8	0.4
2000	69 031	62.0	0.6
2001	68 845	61.2	-0.3
2002	71 032	61.8	3.2
2003	72 275	61.8	1.7
2004	72 947	60.4	0.9
2005	74 368	61.2	1.9
2006	75 812	61.3	1.9
2007	76 890	61.8	1.4
2008	78 371	62.4	1.9
2009	80 658	61.8	2.9

Source: Statistics Canada, *Electric Power Generating Stations* (Cat. No. 57-206-XIB).

Hydroelectricity

Hydroelectricity is a renewable form of electricity generated from a system or technology that uses a mechanical method to capture and convert the kinetic energy of water.

TABLE 5-2

Renewable Energy Technologies Used in Canada

Electricty – Commercial	Mechanical power
Hydroelectric dams	Wind water pumps
Tidal barrages	**Thermal energy**
In-stream current devices	Biomass (e.g. roundwood, pellets, wood chips)
Biomass (e.g. wood waste)	Ground-source heat pumps (i.e. earth energy)
Biogas (e.g. methane from landfill sites)	Solar air-heating systems
Wind turbines	Solar hot water systems
Photovoltaic systems	
Electricity – In development	**Transportation**
Wave systems	Biodiesel
Tidal systems	Ethanol from biomass

Hydro is the main source of electricity in Canada, accounting for approximately 62 percent of the electricity generated in 2009. Canada's hydro supply is dominated by large-scale projects developed by electric utilities. Of the 76 648 megawatts (MW) of installed hydro capacity, 3 372 MW come from small hydro sites (capacity less than 50 MW), representing 2.6 percent of Canada's total installed electricity capacity. Significant potential remains for additional large and small run-of-river hydroelectric development in most provinces and territories.

Biomass

Biomass provides a renewable source of energy derived from the conversion of matter from living organisms or metabolic by-products. Canada has an abundant supply of many types of biomass, which is important for the production of energy, biofuels, materials and chemicals. The two largest sources of biomass supply in Canada are forestry and agricultural operations.

Biomass supply typically takes the following forms:

- forestry – mill or pulp-and-paper residues, black liquor from the pulping process, forest residue, forest management thinnings and short-rotation crops
- agriculture – agricultural crops, crop residue, processing residues, algae and aquatic biomass
- other organic waste – animal waste, such as manure from feed lots, municipal solid waste and industrial wastes

Approximately 4.5 percent of Canada's total energy supply comes from bioenergy, second only to hydro power (which generates 12.4 percent of Canada's energy). Most of the bioenergy produced is in the form of industrial process heat, electricity and residential space heating.

The pulp and paper and forest industries are Canada's major producers and users of bioenergy. In 2009, 673 MW of biomass generating capacity came from spent pulping liquor used in the pulp and paper industry. This amount represents approximately 40 percent of the total biomass generating capacity, while 51 percent of the capacity (853 MW) came from wood refuse used in the forestry industry.

Heat and electricity produced by industry, electricity generated by independent power producers and residential wood heat are considered commonplace in Canada's energy mix. For example, approximately 3 million Canadian households use wood for home heating. Roundwood is typically used but alternatives include wood chips and pellets. Wood for home heating is usually burned in stand-alone wood stoves, wood furnaces with hot water or forced-air systems, fireplaces with advanced combustion inserts, high-efficiency fireplaces or high-thermal-mass masonry heaters.

Use of biogas and landfill gas (methane-rich gases that are derived from manure, animal processing wastes, other agricultural residues and municipal waste) for energy production is just emerging.

In 2009, the biomass installed generating capacity was 1 671 MW, of which 8.7 percent was from landfill gas plants (110 MW) and municipal solid waste plants (35 MW). Approximately 200 million litres (L) of fuel ethanol are produced annually in Canada from cereal grain and corn. Biodiesel is also produced in small quantities, but production is increasing. Canada has the potential to increase its bioenergy production in a sustainable manner.

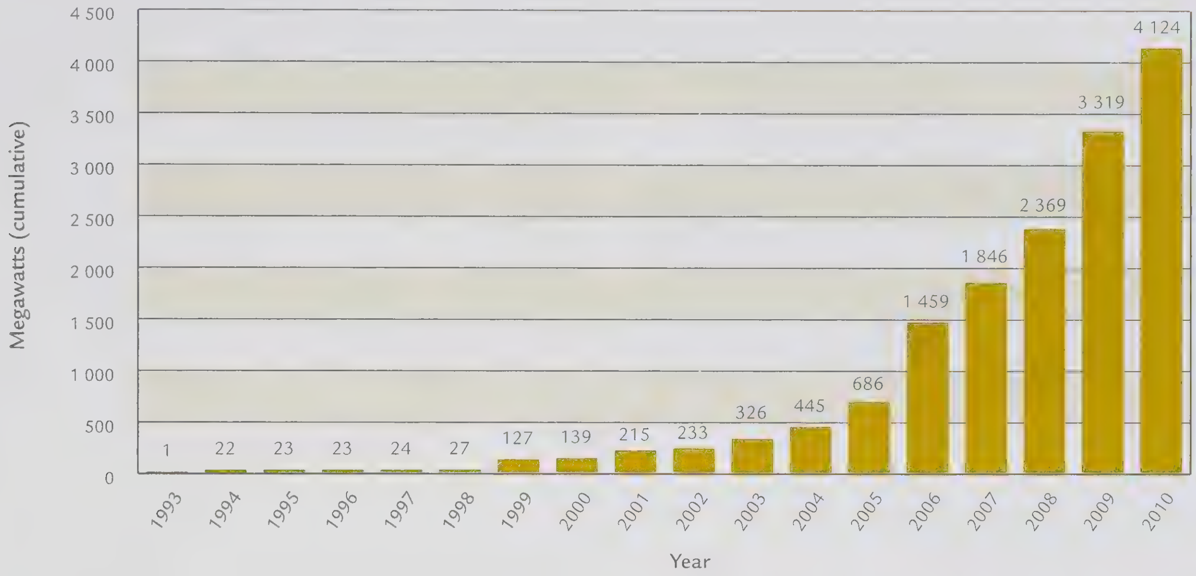
Earth Energy

As a result of the sun heating the surface of the planet, and because of the insulating qualities of the earth itself, the temperature 1 or 2 metres below the surface remains fairly constant – between 5°C and 10°C. This temperature is warmer than that of the air during the winter and cooler than that of the air in the summer.

Geothermal energy can be used as a heat source or sink for heating or cooling applications, such as ground-source heat pumps (GSHPs). GSHPs are electrical systems that use the relatively constant temperature of the ground to provide heating, cooling and hot water for homes and commercial buildings.

FIGURE 5-1

Canadian Wind Power Cumulative Capacity, 1993 to 2010



Source: NRCan and the Canadian Wind Energy Association.

For this reason, a GSHP is also known as an earth energy system (EES). During winter, EES installations remove heat from the earth using a liquid, typically an antifreeze solution or water that circulates within an underground loop. The EES then upgrades the heat with a conventional heat pump and transfers it to indoor space or the water-heating system. During summer, the system reverses this process to operate as an air conditioner. EES installations supply less than 1 percent of the market for space and water heating and cooling in Canada.

In 2009, 15 643 GSHP units were installed in Canada. This compares with 14 879 units installed in 2008 and 9 284 units installed in 2007. As of December 31, 2009, there were approximately 83 000 GSHPs representing about 1 000 megawatts of thermal energy (MW_{th}) of installed capacity and producing an estimated 1 370 gigawatt-hours equivalent annually.

Wind Energy

Wind turbines convert the kinetic energy of wind into electrical or mechanical energy. Canada's land mass and coastal waters combine to provide a wind resource with potential estimated at more than 100 000 MW.

As of December 31, 2009, 3 319 MW of wind power had been installed in Canada. This makes Canada the country with the ninth largest installed wind energy capacity. As of March 31, 2011, there were 4 825 MW of wind power in operation in 133 wind farms in all provinces in Canada.

The best year in terms of wind power installations was 2009, with 950 MW of new wind power generating capacity installed across the country, representing a 40 percent increase from the 2008 level (2 369 MW) (see Figure 5-1). Federal and provincial policies continue to spur growth in the Canadian wind industry.

Wind energy also provides mechanical power. Several thousand wind-powered water pumps are used throughout Canada, mostly in the Prairie provinces. As well, Canadians use small, residential-sized wind turbines to power cottages and remote houses.

Solar Energy

Three main technologies use energy from the sun:

- passive solar technologies – buildings are designed and located to maximize their reception of solar energy
- active solar thermal systems – solar radiation is converted into thermal energy for heating air or water in residential, commercial and industrial applications
- solar electric (photovoltaic [PV]) systems – solar radiation is used to produce electricity

The Canadian active solar thermal installed capacity in 2010 was 1 025 600 square metres (m^2), or approximately 712 MW_{th}. The domestic market increase has averaged 13 percent annually since 1998. In 2010, the solar thermal collector market in Canada was 179 360 m^2, 38 percent more than the installations in 2009 (130 000 m^2).

Solar PV energy also experienced high rates of capacity growth – about 38 percent average growth rate annually between 1992 and 2010 – even though it started from a low baseline. So far, 2010 has been the best year for solar PV, with an estimated total installed capacity of 290 MW, representing an increase of 196 MW from the previous year. This significant growth was spurred primarily by two programs from the Government of Ontario: a renewable energy standard offer program launched in 2006 and the new feed-in tariff program launched in 2009.

Ocean Renewable Energy

Ocean renewable energy refers to the use of ocean waves, current and tides to generate electricity. Devices that capture ocean or tidal currents can also be deployed in rivers and streams.

Since 1984, Canada has had the only commercial tidal energy facility in North America — the 20-MW plant in Annapolis, Nova Scotia. However, like wave and current devices, the next generation of tidal power generators is in an early stage of development, and as yet no commercial facilities have been proposed.

British Columbia and Nova Scotia are taking steps to support the development of the next generation of ocean renewable energy technologies, which use waves, ocean currents and tides to generate electricity.

In 2010, the Fundy Ocean Resource Centre for Energy, a technology demonstration facility, started testing three technologies with a total capacity of 4 MW. Wave and tidal-current technologies are also being tested off the coast of British Columbia, and a commercial facility for generating electricity may be feasible within the next decade.

Canada is well poised to become a leader in global technology development and deployment. Canadian technology developers are planning and testing devices, and several demonstration projects are underway.

PULP AND PAPER GREEN TRANSFORMATION PROGRAM

Objective

The Pulp and Paper Green Transformation Program (PPGTP) was created to fund projects resulting in demonstrable environmental benefits at Canadian pulp and paper mills, leading to improved environmental and commercial sustainability of the sector.

DID YOU KNOW?

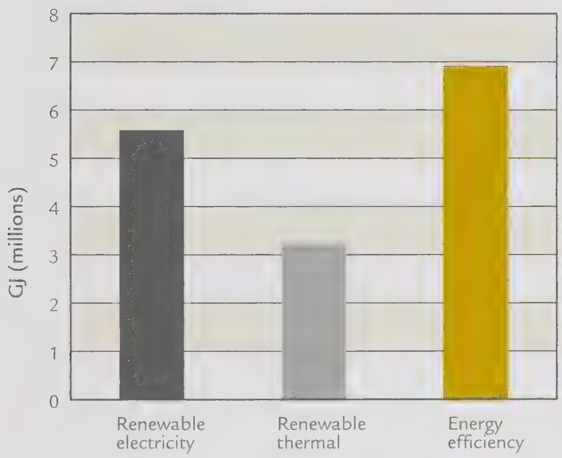
In 2010, the Zellstoff Celgar pulp mill in British Columbia completed the first phase of its green energy project as part of the PPGTP. This phase has allowed Celgar to use the excess steam produced by its industrial processes to generate large amounts of renewable electricity for export to the B.C. grid. Other environmental benefits from the project include a reduction in sulphur dioxide emissions, increased energy efficiency and reduced odour and noise in the community.

Description

The $1-billion PPGTP was launched in June 2009. It supports innovation and environmentally friendly investments in Canada's pulp and paper industry in areas such as energy efficiency and renewable energy production. In October 2009, credits were allocated to 24 companies, based on black liquor production ($0.16/L) at 38 pulp and paper mills. Companies have until March 31, 2012, to invest their credits at any of their Canadian pulp and paper mills in approved green capital projects that lead to measurable environmental benefits. Renewable energy generation and energy savings from energy efficiency improvements associated with PPGTP projects signed as of March 31, 2011, are shown in Figure 5-2.

FIGURE 5-2

Achievements Resulting From PPGTP Investments



Source: Natural Resources Canada. Pulp and Paper Green Transformation Program. Environmental Benefits Tracking Spreadsheet. 2011.

Key 2010–2011 Achievements

- As of March 31, 2011, contribution agreements had been signed for 75 projects with 22 companies, with funds requested totalling $844 million. Approximately $388 million was expended in 2010–2011 under these agreements.
- As of March 31, 2011, PPGTP projects with signed agreements were expected to support the creation of 185 MW of renewable electrical capacity and save 6.9 million gigajoules of energy per year.
- These projects were also expected to reduce mills' greenhouse gas (GHG) emissions by 336 000 tonnes per year.

DID YOU KNOW?

The expected annual energy savings resulting from signed PPGTP projects are enough to power more than 160 000 homes – the number of homes in Hamilton, Ontario!

For more information:

cfs.nrcan.gc.ca/subsite/pulp-paper-green-transformation

INVESTMENTS IN FOREST INDUSTRY TRANSFORMATION

Objective

The Investments in Forest Industry Transformation (IFIT) program supports Canada's forest sector in becoming more economically viable and environmentally sustainable through targeted investments in innovative technologies.

Description

IFIT is providing $100 million over four years for projects that implement new technologies leading to non-traditional, high-value forest products and renewable energies. By building on the success of previous federal investments in research and development, IFIT ensures that promising breakthrough technologies in the forest sector continue to evolve toward full commercial viability.

Key 2010–2011 Achievements

- Successful program development and launch in summer 2010, followed by a call for proposals that attracted more than 60 applications from companies across Canada representing various forest industry subsectors, company and project sizes, and technology types.

- Signed the first round of contribution agreements worth $6.6 million for projects focusing on waste heat recovery and methanol purification; the latter is the first application in the world of this particular technology.

For more information:
forest-transformation.nrcan.gc.ca

Natural Resources Canada carried out two initiatives to increase the use of renewable energy in Canada: ecoENERGY for Renewable Power and ecoENERGY for Renewable Heat. The two programs are outlined below.

ecoENERGY FOR RENEWABLE POWER

Objective

To encourage the production of 14.3 terawatt hours of electricity from low-impact renewable energy sources (about 4 000 MW of new capacity), such as wind, hydro, biomass, solar PV and ocean energy. The program was launched on April 1, 2007.

Description

The ecoENERGY for Renewable Power program provides an incentive of one cent per kilowatt hour to an eligible low-impact renewable energy project for up to 10 years. Eligible recipients include businesses, institutions/organizations, independent power producers, public and private utilities, and co-operatives that install qualifying renewable power systems. Qualifying projects must have a total rated capacity of 1 MW or greater. The program had authority to sign contribution agreements with renewable energy developers until March 31, 2011, but many projects with contribution agreements will continue to receive payments as outlined in contribution agreements and up to March 31, 2021.

Key 2010–2011 Achievements

- As of March 31, 2011, 104 contribution agreements had been signed with proponents, representing about $1.4 billion in federal funding over 14 years and 4 458 MW of renewable power capacity.
- The GHG emission reductions from full-year operations for the 104 projects are expected to be about 6 megatonnes per year.

For more information:
ecoaction.gc.ca/ecorp

ecoENERGY FOR RENEWABLE HEAT

Objective

To increase the use of renewable energy technologies, develop thermal energy industry capacity and contribute to the reduction of harmful emissions. This four-year program was launched April 1, 2007.

Description

The ecoENERGY for Renewable Heat program supported renewable thermal technologies used for space heating and cooling and water heating, through a mix of deployment incentives, residential pilot projects and industry capacity-development funding:

- deployment incentive – providing a financial contribution to encourage the deployment of solar thermal units in the industrial, commercial and institutional sectors
- residential pilot projects – providing financial contributions to test, through collaborative ventures, various approaches to the large-scale deployment of solar water-heating units in the residential sector
- industry capacity-development – providing financial contributions to develop technology standards and certification processes for solar thermal technologies, human resources skills and tools and to provide public information for renewable thermal energy technologies

Key 2010–2011 Achievements

- Installed 523 solar thermal systems in the industrial, commercial and institutional sectors.

- Coordinated the federal program with complementary programs in British Columbia, Saskatchewan and Ontario.
- Through contribution agreements with 14 partners (utilities, developers and buyers' groups, tested large-scale methods to deploy solar-heated water in the residential sector. Under these agreements, 575 solar water-heating systems were installed in the fiscal year.
- Completed, through the Association of Canadian Community Colleges, national curricula for solar thermal and PV installers and designers.
- The estimated GHG reductions from systems installed under the program during 2007–2008, 2008–2009, 2009–2010 and 2010–2011 are 3.3, 5.1, 8.2 and 9.5 kilotonnes (kt), respectively. The cumulative annual GHG reductions from the program from these installations are 25 kt.

For more information:
ecoaction.gc.ca/heat

CHAPTER 6 Co-operation

INTRODUCTION

This chapter describes Natural Resources Canada's (NRCan's) co-operation with provincial and territorial governments and internationally on efficiency and alternative energy (EAE) during the reporting period. Examples of program co-operation on specific EAE initiatives are included in the "Key Achievements" sections of earlier chapters.

Municipal governments and agencies participate in NRCan's EAE measures as clients (for training workshops, as recipients of financial incentives, etc.) and as partners (e.g. in idle-free projects). At the same time, NRCan participates in ventures led by municipal organizations, such as the Green Municipal Fund (see accompanying textbox), and by provincially and territorially regulated electricity utilities and provincially regulated natural gas utilities.

Several institutions in Canada address energy efficiency issues in broad terms, including the three data and analysis centres established by NRCan, the host universities and other partners. Their main objectives are to facilitate access to data on energy use in the industry, transportation and building sectors; monitor the quality of data; develop expert knowledge; and investigate methods of improving data collection and analysis. Since their establishment, these centres have also been sponsored by various entities, including other federal departments, provincial government agencies, industry associations and energy supply utilities.

There are two national consultative bodies in the area of energy efficiency: the Steering Committee on Energy Efficiency (SCEE), established under the

Green Municipal Fund

The Government of Canada endowed the Federation of Canadian Municipalities (FCM), a non-profit organization, with $550 million to establish the Green Municipal Fund (GMF) for the purpose of providing a long-term, sustainable source of funding for municipal governments and their partners. The GMF invests in plans, studies and projects that offer the best examples of municipal leadership in sustainable development and that other Canadian communities can replicate.

Under the GMF agreement, the Government of Canada (represented by NRCan and Environment Canada) participates in governance of this revolving fund, along with representatives from the public and private sectors, including municipal officials and technical experts, through a peer review committee and an advisory council.

The FCM board of directors approves projects in light of the council's recommendations. As of March 31, 2011, the GMF had committed $555.2 million for more than 870 sustainable community plans, feasibility studies, field tests and capital projects with the potential to leverage more than $3 billion of economic activity in approximately 430 Canadian communities. Actual environmental benefits include the reduction of an estimated 175 000 tonnes of carbon dioxide annually from 40 completed capital projects.

More details can be found in the *Green Municipal Fund Annual Report 2010–2011* at sustainablecommunities.fcm.ca/About_Us/Annual_Reports/.

Council of Energy Ministers; and the Office of Energy Efficiency's (OEE's) National Advisory Council on Energy Efficiency (NACEE).

STEERING COMMITTEE ON ENERGY EFFICIENCY

Established in 2004 by the Council of Energy Ministers (which comprises federal, provincial and territorial energy ministers), the SCEE is tasked with establishing a coordinated, complementary agenda for energy efficiency in the built environment, industry and transportation sectors. In fiscal year 2010–2011, the SCEE held a number of teleconference calls, as well as two face-to-face meetings – in Ottawa and Halifax – with members representing the federal, provincial and territorial governments.

The efforts of the SCEE and its working groups facilitated the energy efficiency discussions at the September 17, 2010, meeting of the Council of Energy Ministers (held under the auspices of the Energy and Mines Ministers' Conference). This discussion focused on innovative energy efficiency practices from around the world, specifically examining lessons learned and best practices of note within the context of energy efficiency in Canada. Ministers discussed how they could help enhance existing programs and support emerging technologies for residential and commercial buildings while creating a culture of innovation that will support job growth. Ministers also called for continued collaboration on measures to improve energy efficiency, including the following:

- publishing an updated model energy code for buildings in 2011 and committing to a cycle of further improvement
- collaborating on next-generation home energy-rating systems to support labelling and codes
- strengthening the capacity of the commercial buildings sector to finance energy efficiency projects

These efforts and others are coordinated by the three working groups that operate under the SCEE. Responding to the Ministers' direction, the working groups undertake ongoing actions to develop concrete energy efficiency initiatives consistent with the themes and ideas first expressed in *Moving Forward on Energy Efficiency in Canada: A Foundation for Action*, developed by the Council of Energy Ministers in 2007. These initiatives may be delivered by multiple jurisdictions and in conjunction with key stakeholders.

- Formed in 2003, The Built Environment and Equipment Working Group (BEEWG) has members representing NRCan, industry and all provinces and territories. Its subcommittees perform collaborative tasks related to
  - the *National Energy Code for Buildings*
  - building energy benchmarking
  - the commissioning and recommissioning of buildings
  - energy-efficient equipment
  - integrated community energy solutions
  - lower-income-household energy efficiency options
  - the accelerated penetration of energy-efficient home retrofits
  - energy efficiency financing in the commercial/institutional sector

  The subcommittees undertook work on the following:

  - a national campaign with utilities on ENERGY STAR® qualified lighting fixtures
  - a retailer study on the availability of energy-efficient lighting products, with messaging to their employees and consumers
  - expanding the scope of standby power to include consideration of other consumer electronics issues

- agreement on long-term performance targets for gas water heaters, and further collaboration to validate their performance and identify consumer issues
- a prototype residential electricity audit was piloted in 400 homes in five provinces
- the completion of a major energy-use survey of Canada's commercial and institutional buildings sector that will provide reference case information for developing a buildings' energy benchmarking tool using a Canadian version of the U.S. Environmental Protection Agency's Portfolio Manager, a building benchmarking tool
- the production of tools to aid building owners in achieving new investment opportunities
- an announcement by the Canadian Standards Association of the first national standard on the commissioning of buildings for achieving and documenting the optimal performance of a complete building and its major systems
- encouraging the recommissioning of commercial/institutional buildings

- The mandate of the Transportation Working Group on Energy Efficiency (TWGEE), formed in 2005, is twofold: to assess the status and enhance the alignment of transportation energy efficiency activities across federal, provincial and territorial jurisdictions; and to investigate opportunities for further collaboration and new initiatives. The TWGEE comprises government officials from federal and provincial energy and transportation departments and ministries. In 2010–2011, the TWGEE developed a heavy-duty-vehicle tire recognition framework that can be used in Canada to promote the purchase of fuel-efficient tires for heavy-duty vehicles. The framework takes into account the winter traction research that was commissioned by the TWGEE.
- The Industry Working Group on Energy Efficiency (IWGEE) was formed in 2006 to promote information exchange among industrial energy end-users and authorities, agencies, utilities and jurisdictions involved in the design, development and delivery of industrial energy efficiency programming in Canada. Since fiscal year 2009–2010, the IWGEE has worked on developing the international ISO 50001 energy management systems standard. The first Canadian energy management systems standard was published in summer 2011. Working with the Canadian Standards Association, NRCan has established four task groups to develop a roadmap to facilitate the early implementation of ISO 50001. IWGEE also initiated the development of a training workshop for energy management information systems.

NATIONAL ADVISORY COUNCIL ON ENERGY EFFICIENCY

NACEE was created in April 1998 to assist the OEE as an innovative government organization by

- assessing and advising on the OEE's strategic approach to meeting federal policy objectives
- advising the OEE on its performance and business planning and reporting on progress
- considering issues related to accelerating growth in energy efficiency in the Canadian economy

NACEE membership is drawn from across Canada. It includes representatives from various levels of government, academia, economic sectors, energy utilities and advocacy groups. NACEE met twice during the 2010–2011 fiscal year.

FEDERAL-PROVINCIAL-TERRITORIAL CO-OPERATION

There is continuing interest in energy efficiency as a powerful means of maximizing the services obtained from Canada's existing energy supply capacity. In addition to general co-operation on energy efficiency, provincial and territorial governments helped to deliver or employ tools provided by federal EAE programs to reduce energy costs, address climate change, increase competitiveness, improve air quality and create economic opportunities. Coordination between the federal and provincial/territorial levels has aided all parties in avoiding duplication and ensuring efficient program delivery.

All provinces and territories engage in energy efficiency activities and/or deliver energy efficiency programs in their jurisdictions. In some provinces and territories, specific organizations are mandated to promote energy efficiency. Examples include the following:

- The Manitoba Hydro Power Smart program is widely recognized for its effective, user-friendly tools for homeowners, businesses and industry to boost energy efficiency and save significantly on energy costs.
- The Ontario Power Authority's Conservation Bureau provides leadership in planning and coordinating measures for electricity conservation and load management.
- The Yukon Energy Solutions Centre is a service and program delivery agency for federal and Yukon government programs on energy efficiency and green power.
- Efficiency NB promotes energy efficiency measures across the residential, community and business sectors of New Brunswick, developing and delivering programs and initiatives to achieve this objective.

The provinces have been promoting the use of renewable energy for electricity generation. They provide numerous incentives, including voluntary renewable energy targets, legislated renewable

Use of Federal EAE Program Tools by Utilities, Provinces and Territories

Provincial and territorial governments and utilities use federal EAE program tools to complement their own energy efficiency programs. Here are some examples:

- Homeowners in all regions of Canada, except one territory, were able to access both provincial/territorial and federal home retrofit programs through a single energy evaluation offered under ecoENERGY Retrofit – Homes. The ecoENERGY evaluation and its criteria are also used by these jurisdictions to determine eligibility for incentives.
- Canadians in most provinces and territories can benefit from rebates and sales tax exemptions on selected ENERGY STAR qualified products. The ENERGY STAR® Initiative in Canada is administered by the OEE and is used by a number of provinces and utilities as a qualifying criterion.
- NRCan's R-2000 Standard is used by utilities in Manitoba, New Brunswick and Nova Scotia as a qualifying criterion for incentives and rebates designed to encourage the construction of energy-efficient new homes.
- NRCan's EnerGuide Rating System has been used in six provinces and territories to develop or implement energy performance requirements in their building codes or municipal bylaws.
- All the provincial and territorial bodies responsible for driver education, with the exception of Nunavut, use the Auto$mart Driver Education Kit, developed by the OEE, to educate young drivers on fuel efficiency. For example, Manitoba Public Insurance and the Province of Ontario have recently incorporated a component on fuel efficiency into their driver education curricula. Also, many provinces display the OEE's publications in their licensing bureaus.

portfolio standards and the procurement of renewable energy through requests for proposals, standard offers and feed-in tariff programs.

Sustainable Development Technology Canada – NextGen Biofuels Fund™

The NextGen Biofuels Fund™ is a $500-million program scheduled to run from 2008 to 2017. Responsibility for the program is held jointly by NRCan and Environment Canada. The fund is managed under the auspices of Sustainable Development Technology Canada (SDTC).

The NextGen Biofuels Fund™ aims to facilitate the establishment of first-of-a-kind, large, demonstration-scale facilities for the production of next-generation biofuels and co-products in Canada; improve the sustainable development impacts arising from the production and use of biofuels; and encourage retention and growth of technology expertise and innovation capacity for the production of next-generation biofuels.

Next-generation renewable fuels are derived from non-traditional renewable feedstocks – such as forest biomass, fast-growing grasses and agricultural residues – and are produced with non-conventional conversion technologies. An eligible project must use feedstocks that are or could be representative of Canadian biomass, and the technology must have been demonstrated at the pre-commercial pilot scale. SDTC supports up to 40 percent of eligible project costs.

In 2010–2011, SDTC saw increased interest in the fund, largely attributable to progress on the technology and pre-commercial demonstration projects and the global economic recovery. SDTC is following more than 100 companies, with 20 companies showing high potential for promising technologies.

The Building Energy Codes Collaborative

The Building Energy Codes Collaborative (BECC) is a federal-provincial-territorial committee supported by the Council of Energy Ministers, the SCEE and NRCan. BECC is made up of representatives from provincial/territorial code and energy ministries, departments and agencies; NRCan; and the Canadian Codes Centre. The objectives of BECC are as follows:

- provide a forum for provinces, territories and the Government of Canada to support the update, regulatory adoption and implementation of the *National Energy Code for Buildings* (NECB), by responsible authorities
- work in co-operation with the provinces and territories and the Canadian Commission on Building and Fire Codes toward a national consensus on establishing energy efficiency in the code process
- explore other regulatory and/or program instruments for increasing energy efficiency in new housing, including updating the *National Energy Code for Houses*

NRCan and BECC prepared a business plan for updating the 1997 NECB and presented it to the Canadian Commission on Building and Fire Codes. Commission members unanimously approved the following motion at its annual meeting in Calgary in February 2007: ". . . that the updating of the MNECB as a progeny document based on the BECC Business Plan be approved."

NRCan then prepared and signed a memorandum of understanding (MOU) with the National Research Council Canada (NRC). Under this MOU, NRCan contributed up to $4 million over four years to support the technical development of the new code and is providing technical expertise to the NRC team tasked with developing national codes. The NRC launched the project, and the Standing Committee on Energy Efficiency in Buildings held its first meeting on updating the code in Ottawa in December 2007.

The updated NECB was published in 2011 in an objective-based format. It complements objective-based model national construction codes published in 2005.

Co-operation Agreements

NRCan's memorandum of agreement (MOA) on EAE with the Agence de l'efficacité énergétique du Québec provides for consultation and sharing of information between the two governments, the coordination of EAE activities in Quebec and the creation of opportunities for joint projects. Further, the management committee established under the MOA reviews policy and program developments, progress on joint program initiatives and areas for further co-operation. NRCan is working with the Agence de l'efficacité énergétique to deliver services under the ecoENERGY programs.

The MOA played a role in facilitating three activities in particular:

- management of the licensing agreement for local delivery of ecoENERGY Retrofit – Homes
- continued processing of payments by the OEE's Buildings Division for the former EnerGuide for Existing Buildings and Commercial Building Incentive programs under a letter of co-operation (LOC) with the Agence de l'efficacité énergétique. Though the two programs are now closed, payments, which can be made only when the client verifies that work has been completed, are still being processed.
- signing a three-year collaboration agreement with CanmetENERGY and the Agence de l'efficacité énergétique to help refrigerated facilities (ice and curling rinks, supermarkets, warehouses) in Quebec reduce their energy consumption and greenhouse gas (GHG) emissions through the *Programme d'optimisation en réfrigération* (OPTER). This program is based on the CoolSolution approach developed by CanmetENERGY. CanmetENERGY provides technical support and training for consultants and decision-makers.

NRCan has entered into a number of contribution agreements over the past years with the Yukon Energy Solutions Centre in Whitehorse on projects related to energy efficiency. The Centre provides access to technical services and programs for the Yukon population and undertakes outreach and public education activities.

NRCan is committed to promoting energy efficiency and renewable energy with the provinces and territories. Notable collaborations include working with the following:

- the Office of the Fire Commissioner of Manitoba, a special operating agency of Manitoba Labour and Immigration, to engage Manitoba stakeholders in a review of the Energy Code Advisory Committee recommendations and to establish minimum code requirements for energy and water efficiency in new and renovated Part 3 buildings in the province
- the Province of Manitoba, which is consulting stakeholders on introducing water efficiency in the plumbing code and identifying barriers in the *Manitoba Building Code* to energy and water efficiency in buildings. The result will be a stakeholder consultation report provided to Manitoba's Minister of Labour and Immigration and Minister of Science, Technology, Energy and Mines.
- Efficiency NB to develop a customized version of the *Advanced Buildings Core Performance Guide* produced by the New Buildings Institute, which will assist the New Brunswick design and construction community in applying a step-by-step "prescriptive" program to help achieve predictable energy savings of 30 percent better than those of the NECB
- Efficiency New Brunswick, Conserve Nova Scotia, and the Office of Energy Efficiency of Prince Edward Island, which have agreed to collaborate on a study that will establish a baseline that depicts the current state of the energy performance of new commercial buildings in the Maritimes
- Efficiency NB to facilitate access to the ecoEnergy Retrofit – Small and Medium Organizations program by the owners of small and medium-sized buildings

- the Canadian Standards Association to develop Canada's first edition of the new national standard on commissioning of buildings
- the Ontario Ministry of Municipal Affairs and Housing to investigate next reasonable steps (levels) that Ontario's construction sector could take when complying with the 2011 NECB and to analyse the impacts of potential requirements, including cost, enforcement and industry-capacity impacts
- Productivity Alberta, industry associations and utilities to provide energy management training to companies across Canada through Dollars to $ense workshops
- Climate Change Central, a non-profit corporation in Alberta funded by several stakeholders, including the Government of Alberta, which focuses on information and action on energy efficiency and conservation in the province

Atlantic Energy Gateway

The Atlantic Energy Gateway (AEG) Initiative is a $4-million joint initiative of NRCan and the Atlantic Canada Opportunities Agency aimed at facilitating co-operation among Atlantic provinces toward the development of the region's clean energy resources.

In 2010, the AEG Federal-Provincial DM Coordinating Committee approved the AEG work plan, which includes collaborative research studies that will provide insight into the challenges and opportunities involved in maximizing the benefits of developing clean energy in the Atlantic region. Over the remaining course of fiscal year 2010–2011, federal, provincial and utility officials began implementing the work-plan elements.

INTERNATIONAL CO-OPERATION

NRCan co-operates with several international organizations in EAE program areas and supports bilateral EAE co-operation with China, India, Russia, Mexico and the European Union, for example.

Canada benefits from this co-operation by

- learning about improved ways of designing and delivering EAE programs to meet policy objectives
- working with others on the harmonization of energy efficiency tests and performance standards to reduce barriers to trade in energy-using products (in this regard, NRCan provides input, as requested, to Foreign Affairs and International Trade Canada on prospective free trade agreements and on technical barriers to trade)
- sharing tools and resources with other international partners, such as the U.S. Department of Energy, in the development of ISO 50001, an Energy Management Standard that will help guide industry on best management practices and technical practices to reduce energy waste

International Energy Agency

The International Energy Agency (IEA), based in Paris, France, is an autonomous agency of the Organisation for Economic Co-operation and Development. The IEA runs a comprehensive program of energy co-operation among its 28 member countries, including Canada. IEA member governments have committed to sharing energy information, coordinating energy policies and co-operating on the development of national energy programs incorporating energy security, economic development and environmental protection. The IEA and its Governing Board are assisted in their work by several standing groups and special committees, which bring together energy specialists from member countries.

The Standing Group on Long-Term Co-operation (SLT) is the key IEA committee on the policy side. The SLT analyses policies to promote conservation and the efficient use of energy, as well as measures to

increase long-term energy security while protecting the environment. The SLT monitors energy developments in member countries and makes recommendations on energy policy through a regular series of individual country reviews, including the *Energy Policies of IEA Countries – Canada – 2009 Review*, which was released in April 2010. The SLT's Energy Efficiency Working Party (EEWP) provides advice on and direction to the IEA's work on specific energy efficiency issues. The OEE represents Canada on the EEWP. In 2009–2010, the IEA released a report card to the Group of Eight (G8) that recognized Canada as one of the top four IEA member countries that has fully or partially implemented the IEA's recommendations on energy efficiency.

Canada's international energy research and development (R&D) objectives are mainly advanced through the IEA's working parties, implementing agreements, and experts groups that are under the Committee for Energy Research and Technology. Canada participates in 31 of the IEA's 40 implementing agreements on R&D collaboration programs. NRCan contributed $979,000 to IEA implementing agreements in 2010–2011. One such agreement is the IEA Implementing Agreement for a Co-operating Programme on Efficient Electrical End-Use Equipment (4E). This agreement brings together energy efficiency policy-makers from Asia, Europe and North America to encourage the use of more efficient appliances (e.g. solid state lighting, electric motor systems and standby power). Co-operation through implementing agreements has helped to accelerate technology development and set the stage for technology deployment in Canada, generating benefits that far outweigh the direct costs of collaboration.

Canada also co-operates with research centres in IEA member countries on several R&D and technology agreements and programs outside the IEA. NRCan, together with Foreign Affairs and International Trade Canada, facilitates R&D and commercial business ventures abroad by Canadian firms by undertaking a wide variety of activities. These activities include participating in various IEA tasks and supporting technical and trade-oriented workshops and conferences.

CanmetENERGY was named the operating agent of the new IEA Annex 54, "Integration of Micro-generation and other Energy Related Technologies in Buildings." The research program will focus on improved models of poly-generation and/or hybrid type micro-generation systems. The purpose is to better assess the application of these systems, to identify the impact on energy use and GHG emissions and to investigate the competitiveness of these micro-generation systems in relation to other technologies. Participants are from 14 countries in Europe, Asia, Japan and North America and represent 24 research organizations, academia and private companies.

Canada also participates in the IEA Implementing Agreement for Renewable Energy Technology Deployment (IEA-RETD). Created in 2005, IEA-RETD is a cross-cutting, policy-focused agreement about furthering the deployment of renewables. It undertakes studies to inform policy-makers and other stakeholders on topical issues about the large-scale deployment of renewable energy technologies and organizes international events on related issues. A list of completed and ongoing projects and events is available on the IEA-RETD Web site at www.iea-retd.org.

International Partnership for Energy Efficiency Cooperation

NRCan participated in the development of an agreement establishing the International Partnership for Energy Efficiency Cooperation (IPEEC). This agreement was formally signed by Canada and 11 other countries during the G8 Energy Ministers Meeting in May 2009. The partnership supports the on-going energy efficiency work of the participating countries and relevant international organizations. The IPEEC Executive Committee and IPEEC Policy Committee both continued to meet in 2010–2011. A key component of the IPEEC framework is task groups that pursue projects that interest most,

but not all, IPEEC member countries. Canada participates in the Sustainable Buildings Network Task Group, the Global Superior Energy Performance Partnership Task Group and the Super-efficient Equipment and Appliance Deployment Initiative Task Group.

Global Methane Initiative

CanmetENERGY represents Canada, in collaboration with the Environment Canada Climate Change International Branch, at the international Global Methane Initiative Partnership Steering Committee and co-chairs the initiative's Oil and Gas Subcommittee with Mexico and Russia. CanmetENERGY-Devon R&D projects were showcased at the international Methane to Markets Partnership Expo in Delhi, India, on March 2–5, 2010. These domestic and international projects manage energy and emissions at oil and natural gas production and processing operations.

United Nations

RETScreen® International is managed under the leadership of NRCan's CanmetENERGY. The RETScreen Clean Energy Project Analysis software, provided free-of-charge, can be used worldwide to evaluate the energy production and savings, costs, emission reductions, financial viability and risk for various types of renewable energy and energy-efficient technologies. RETScreen is managed through cost- and task-shared collaborative ventures with other governments and multilateral organizations and with technical support from more than 350 experts representing industry, government and academia.

Key partners are the NASA Langley Research Center, the Renewable Energy and Energy Efficiency Partnership and the Energy Branch of the United Nations Environment Programme.

Asia-Pacific Economic Cooperation (APEC)

The OEE is a member of the APEC Expert Group on Energy Efficiency and Conservation (EGEE&C), which reports to APEC's Energy Working Group. One of the tasks of the EGEE&C is updating and maintaining the APEC Energy Standards Information System (ESIS). ESIS provides public, up-to-date information on appliance and equipment energy standards and regulations. It also provides links to experts and information related to standards and regulations used by APEC and other economies. NRCan contributes regularly to the database by providing updated information on Canadian equipment standards and labelling and new initiatives.

Asia-Pacific Partnership

The OEE participated through the Asia-Pacific Partnership (APP) on Clean Development and Climate on a task force on standby power data to internationally coordinate its efforts to reduce standby power consumption.

CanmetENERGY participated in the APP on three task forces: the Buildings and Appliances Task Force (BATF), the Renewable Energy and Distributed Power Generation Task Force (REDGTF) and the Cleaner Fossil Energy Task Force (CFETF). The Electricity Resources Branch of NRCan was the federal lead of the Power Generation and Distribution Task Force in 2010.

CanmetENERGY-Devon administered a project to develop guidelines for energy and emissions management at the China National Petroleum Corporation's upstream oil and natural gas facilities. This work was in collaboration with the Environment Canada Climate Change International Branch, APP funding and the U.S. Environmental Protection Agency (EPA). Also, a joint workshop for the APP CFETF and the international Global Methane Initiative Partnership's Oil and Gas Subcommittee was co-hosted at Lake Louise, Alberta, by CanmetENERGY-Devon, Environment Canada and the EPA.

Within the BATF and REDGTF, CanmetENERGY proposed the Net Zero Energy Homes initiative. Under this initiative, Canadian delegates have initiated a collaborative dialogue with BATF and REDGTF partners to establish a formal international partnership that will map the path to achieving net zero energy homes.

Through a series of workshops and design charettes, Canada offered APP member countries an opportunity to set a precedent for housing performance optimization by bringing together the fragmented supply chain to discuss issues facing the sector. Participation from the project leaders of the existing BATF and REDGTF projects has ensured synergies. The workshops prominently featured Canadian industries, case studies and research, development and demonstration, potentially leading to commercial and technology transfer opportunities for Canadian firms.

As of May 2010, the APP had endorsed 175 projects and 22 flagship projects. Flagship projects comprise a portfolio of projects and activities that collectively exemplify the vision and objectives of the APP. Canada is involved in 30 APP projects.

Clean Energy Ministerial

The Clean Energy Ministerial (CEM) process was launched by the United States in July 2010 to further collaborate on and accelerate the world's transition to clean energy technologies. Several CEM initiatives cover three main areas: energy efficiency, clean energy supply and clean energy access. Initiatives are led by various countries and include participation from private sector partners and other organizations, such as the IEA. Canada is active in four CEM initiatives. The Global Superior Energy Performance Partnership (also an IPEEC Task Group) aims to accelerate energy efficiency in commercial and industrial buildings. Through this initiative, NRCan is supporting three pilot projects to advance energy management systems. NRCan is also contributing expertise to support information sharing under the Super-efficient Equipment and Appliance Deployment Initiative (also an IPEEC Task Group); the Carbon Capture, Use and Storage Action Group; and the International Smart Grid Action Network.

U.S.-Canada Clean Energy Dialogue

The U.S.-Canada Clean Energy Dialogue (CED) was launched by Prime Minister Harper and President Obama in February 2009. The objective of the CED is to enhance bilateral collaboration on the development of clean energy technologies to reduce GHG emissions. To date, there are three working groups under the CED, and NRCan is involved in two of them: the Electricity Grid Working Group and the Clean Energy Research and Development Working Group. Both focus areas are detailed in the CED Action Plan, which was presented to the Prime Minister and President in September 2009.

The Electricity Grid Working Group is focused on bilateral co-operation facilitating the long-term transition to a modernized electricity system based on clean and renewable generation. The Electricity Grid Working Group Action Plan was developed pursuant to stakeholder consultation as part of an industry round table that occurred in summer 2009.

All remaining elements of the Electricity Grid Working Group Action Plan were implemented by the end of fiscal year 2010–2011. Three major Canada-U.S. conferences addressing themes identified in the Action Plan were held over the course of the fiscal year – one on labour recruitment and retention strategies for addressing workforce challenges in the electricity sector, one on increasing Canada-U.S. trade in clean electricity as a strategy for reducing continental GHG emissions and one on policy issues associated with the transition to a smarter electric grid. Each of these conferences brought together between 80 and 100 senior representatives from government, industry, environmental non-governmental organizations and academic spheres from both countries. Findings and recommendations from the conferences are documented in publicly available reports on a Web site dedicated to the CED.[9] In addition to these conferences, and to further support the objectives of the Action Plan, the Working Group produced two foundation papers on smart grid and energy storage. It also produced a study examining the impacts on and potential benefits to the Canada-U.S. electricity trade from easing trade-constraining elements of existing Renewable Portfolio Standards.

[9] www.changementsclimatiques.gc.ca/Dialogue/default.asp?lang=En&n=E47AAD1C-1

These activities are providing a foundation for continuing progress on the CED.

R&D drives technological discovery and innovation, which are key ingredients in developing the low-carbon energy system of the future. The Clean Energy R&D working group aims to facilitate greater cross-border R&D collaboration by connecting Canadian and U.S. experts and institutions in priority areas for the Clean Energy Dialogue, including future-generation biofuels, clean engines/vehicles, and energy efficiency (homes and buildings). Strengthening collaboration in these areas through joint research, development and deployment will help reduce GHG emissions while strengthening both countries' economies and creating new jobs.

The ENERGY STAR program is an on-going collaborative activity under the Clean Energy R&D Working Group. Expanding collaboration in the program will increase the availability and number of energy-efficient products and appliances and facilitate the harmonization of the North American equipment market.

NRCan's Buildings Division is working with the EPA to develop a Canadian version of the U.S. ENERGY STAR building benchmarking program. The "Measure it, Manage it" Building Energy Benchmarking System tool will allow benchmarking of energy use of building types in both countries. This tool will help building owners, managers and operators and energy utilities track, benchmark and manage energy consumption to reduce GHG emissions and achieve lower operating costs from commercial and institutional buildings.

United States

In addition to collaboration through the Clean Energy Dialogue, Canada also meets annually with U.S. officials through the Canada-U.S. Energy Consultative Mechanism. This mechanism provides a forum for dialogue on policy issues of interest to both countries.

NRCan's OEE signed an MOU with the EPA in September 2005 to share in the common goal of achieving greater energy efficiency and reducing CO_2 through the work of their respective programs: ecoENERGY for Fleets (FleetSmart) and the SmartWay Transport Partnership.

These two programs use a voluntary approach with the on-road freight sector to increase energy efficiency through training, education and the reporting of initiatives. Currently, the MOU is being renewed to further their work on harmonizing program efforts in Canada and the United States.

In 2009, CanmetENERGY, working with the Standards Council of Canada, formed a National Smart Grid Technology and Standards Task Force to provide Canadian input into smart grid standardization activities being led by the U.S. National Institute of Standards and Technology. This process is engaging key stakeholders and regulators in Canada and has enhanced Canada-U.S. collaboration on smart grid interoperability issues.

North America

CanmetENERGY has established partnerships among Canada, the United States and Mexico under the Security and Prosperity Partnership (SPP) of North America to support marine energy research and low-head hydropower demonstrations. CanmetENERGY and other Canadian partners in the SPP program are collaborating with the United States to optimize the rotor design, electricity production and interconnection for the next generation of Verdant Power's *Free Flow* Kinetic Hydropower System, for use in tidal currents and in-stream river applications. Through the same program, CanmetENERGY has created collaborative support for the demonstration of an innovative very low-head hydropower technology in Canada to evaluate the impacts on fish behaviour and the adaptation of the technology for cold climates.

NRCan also continues to work with the United States and Mexico through the Energy Efficiency Experts Group (EEEG) to promote the SPP agenda of harmonizing energy efficiency standards and co-operating on energy efficiency labelling programs. The EEEG is one of nine expert groups of the North American Energy Working Group.

APPENDIX 1 Natural Resources Canada's Efficiency and Alternative Energy Initiatives and Expenditures, 2010–2011

	(millions of dollars)
Energy Efficiency and Alternative Transportation Fuels [1]	**$587.1**
ecoENERGY for Equipment	
ecoENERGY Retrofit – Homes	
ecoENERGY Retrofit – Small and Medium Organizations	
Federal Buildings Initiative	
ecoENERGY for Buildings and Houses	
ecoENERGY for Industry	
ecoENERGY for Personal Vehicles	
ecoENERGY for Fleets	
ecoENERGY for Biofuels	
National Renewable Diesel Demonstration	
National Energy Use Database	

	(millions of dollars)
Energy Efficiency – Energy Science and Technology [2]	**$85.7**
Clean Energy Systems for Buildings and Communities	
Clean Electric Power Generation	
Clean Energy Systems for Industry	
Environmentally Sustainable Oil and Gas	
Clean Transportation Energy	
Sustainable Bioenergy	
Alternative Energy – Renewable Energy Sources	**$527.3**
ecoENERGY for Renewable Heat	
ecoENERGY for Renewable Power [3]	
Pulp and Paper Green Transformation Program	
Investments in Forest Industry Transformation	
Wind Power Production Incentive [4]	
Initiative to Purchase Electricity From Emerging Renewable Energy Sources [5]	
Total	**$1 200.1**

[1] The Energy Efficiency and Alternative Transportation Fuels total does not include the Sustainable Development Technology Canada – NextGen Biofuels Fund™. For details on this Fund, refer to the text box on page [illegible].

[2] Totals allocated for the Program of Energy Research and Development, ecoENERGY Technology Initiative and the Clean Energy Fund in Chapter 4 are reflected in the relevant program entries.

[3] The ecoENERGY for Renewable Power program is fully committed, but incentives will be paid out to recipients until 2020–2021.

[4] The Wind Power Production Incentive is fully committed, but incentives will be paid out to recipients until 2016–2017.

[5] The Initiative to Purchase Electricity From Emerging Renewable Sources is fully committed, but incentives will be paid out until [illegible].

APPENDIX 2 Data Presented in the Report

The aggregate energy use data presented in this report are taken from Statistics Canada's *Report on Energy Supply and Demand in Canada* (RESD). Some adjustments to the original Statistics Canada data were required and are documented in Appendix A of NRCan's *Energy Use Data Handbook, 1990 to 2008*. The differences that exist between this report and *Canada's Energy Outlook* relate to the sector allocations of RESD energy-use data.

Figure 1-1: Secondary Energy Use by Sector, 2008

Sector	Industrial	Transportation	Residential	Commerical/ Institutional	Agriculture	Total
Energy Use (PJ)	3 237.8	2 594.1	1 465.3	1 205.9	217.2	8 720.2
Percentage	37.1	29.7	16.8	13.8	2.5	100.0

Figure 1-2: GHG Emissions From Secondary Energy Use by Sector, 2008

Sector	Transportation	Industrial	Residential	Commerical/ Institutional	Agriculture	Total
GHG emissions (Mt)	179.4	154.0	74.2	65.3	14.8	487.8
Percentage	37.0	32.0	15.0	13.0	3.0	100.0

Figure 1-3: Energy Intensity and the Energy Efficiency Effect, 1990 to 2008

Index (1990 = 1.00)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Energy intensity index	1.00	1.00	1.01	1.00	0.99	0.98	1.00	0.96	0.91	0.89	0.87	0.84	0.85	0.85	0.84	0.81	0.76	0.79	0.78
Index of energy efficiency effect	1.00	0.98	0.97	0.96	0.96	0.93	0.93	0.92	0.89	0.88	0.87	0.85	0.85	0.86	0.84	0.81	0.80	0.82	0.83

Figure 1-4: Secondary Energy Use, Actual and Without Energy Efficiency Improvements, 1990 to 2008

Index (1990 = 1.00)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Estimated secondary energy use without energy efficiency improvements	1.00	1.00	1.03	1.05	1.09	1.15	1.17	1.19	1.20	1.25	1.29	1.28	1.33	1.36	1.39	1.41	1.39	1.45	1.43
Actual energy use	1.00	0.98	1.00	1.02	1.05	1.07	1.11	1.11	1.09	1.13	1.17	1.14	1.18	1.22	1.24	1.23	1.19	1.27	1.26

Figure 1-5: Canadian Households by Type of Dwelling, 2008

Dwelling type	Number of households (thousands)	Percentage
Single detached homes	7 437	56
Single attached homes	1 399	11
Apartments	4 076	31
Mobile homes	252	2
Total	**13 164**	**100**

Figure 1-6: Residential Energy Use by End Use, 2008

Activity	Energy use (PJ)	Percentage
Space heating	920.8	63
Water heating	255.9	17
Appliances	203.0	14
Lighting	62.7	4
Space cooling	22.8	2
Total	**1 465.3**	**100**

Figure 1-7: Number of Households, Average Floor Space by Household and Energy Intensity Indexes, 1990 to 2008

Index (1990 = 1.00)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Number of households	1.00	1.03	1.05	1.07	1.08	1.10	1.12	1.13	1.14	1.16	1.18	1.20	1.21	1.23	1.25	1.27	1.29	1.31	1.33
Average floor space by household	1.00	1.00	1.01	1.01	1.02	1.02	1.03	1.03	1.03	1.03	1.02	1.02	1.02	1.02	1.04	1.06	1.08	1.09	1.09
Energy intensity (GJ/household)	1.00	0.96	0.97	0.98	0.98	0.95	1.01	0.96	0.86	0.89	0.92	0.87	0.89	0.91	0.88	0.86	0.81	0.86	0.86

Figure 1-8: Residential Energy Use, Actual and Without Energy Efficiency Improvements, 1990 to 2008

Index (1990 = 1.00)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Estimated energy use without energy efficiency improvements	1.00	1.04	1.10	1.14	1.14	1.17	1.22	1.20	1.13	1.17	1.24	1.21	1.28	1.31	1.33	1.36	1.33	1.42	1.45
Actual energy use	1.00	0.98	1.01	1.04	1.07	1.05	1.13	1.08	0.99	1.03	1.08	1.04	1.08	1.12	1.10	1.09	1.04	1.12	1.14

Figure 1-9: Annual Heating* Consumption for Houses Constructed to Different Standards

House type	ecoENERGY Retrofit-Homes annual heating* consumption (GJ)	Sample size	Total consumption (GJ)
Typical existing house** (1970)	116	21 616	174
Model National Energy Code house*** (2002)	112	1	143.34
Average** of EnerGuide labelled houses (2009)	55	5 048	110
Average** of R-2000 certified houses	48	3 982	102.23

*DHW and space heating

**National average

***198 m^2, two-storey, single detached house heated with natural gas located in Ottawa, Ontario

Figure 1-10: Average Energy Consumption of New Electric Appliances, 1990 and 2008 Models

Appliance	1990 model (KWh/yr)	2008 model (KWh/yr)
Clothes washers	97	21
Clothes dryers	1 103	916
Dishwashers	227	53
Refrigerators	956	467
Electric ranges	772	522
Freezers	714	375

Figure 1-11: Commercial/Institutional Energy Use by Activity Type,* 2008

Activity type	Energy use (PJ)	Percentage
Offices**	422.4	35
Retail trade	203.6	17
Educational services	152.5	13
Health care and social assistance	131.1	11
Accommodation and food services	88.2	7
Wholesale trade	73.3	6
Transportation and warehousing	47.2	4
Arts, entertainment and recreation	30.8	3
Information and cultural industries	25.9	2
Other services	21.9	2
Total	**1 196.9**	**100**

*Excludes street lighting

** "Offices" includes activities related to finance and insurance; real estate and rental and leasing; professional, scientific and technical services; and public administration.

Figure 1-12: Commercial/Institutional Energy Use by Purpose, 2008

Purpose	Energy use (PJ)	Percentage
Space heating	576.9	48
Auxiliary equipment	232.0	19
Lighting	133.1	11
Auxiliary motors	108.5	9
Water heating	90.6	7
Space cooling	55.7	5
Street lighting	9.1	1
Total	**1 205.9**	**100**

Figure 1-13: Commercial/Institutional Energy Use, Actual and Without Energy Efficiency Improvements, 1990 to 2008

Index (1990 = 1.00)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Estimated energy use without energy efficiency improvements	1.00	1.05	1.08	1.13	1.14	1.16	1.20	1.19	1.17	1.22	1.26	1.26	1.34	1.36	1.37	1.42	1.40	1.47	1.51
Actual energy use	1.00	1.03	1.04	1.08	1.07	1.11	1.13	1.15	1.09	1.13	1.24	1.22	1.31	1.35	1.35	1.34	1.26	1.34	1.39

Figure 1-14: Industrial Energy Use by Subsector – Including Electricity-Related Emissions,* 2008

Subsector	Energy use (PJ)	Industrial energy use (%)
Mining	826.7	25.5
Other manufacturing**	640.7	19.8
Pulp and paper	612.4	18.9
Petroleum refining	337.1	10.4
Smelting and refining	268.7	8.3
Iron and steel	212.3	6.6
Chemicals	200.6	6.2
Construction	60.8	1.9
Cement	60.6	1.9
Forestry	18.1	0.6
Total	**3 237.8**	**100.0**

* The subsectors reflect the current definitions in the *Report on Energy Supply and Demand in Canada*.

** "Other manufacturing" comprises more than 20 manufacturing industries.

Figure 1-15: Cost of Energy to Manufacturing Industries as a Percentage of Total Production Cost, 2008

Industry	Energy cost of total production cost (%)
Cement	22.9
Iron and steel	11.4
Pulp and paper	10.5
Aluminum	9.9
Chemicals	5.0
Petroleum refining	1.5
Transportation equipment and manufacturing	0.7

Figure 1-16: Industrial Energy Use, Actual and Without Energy Efficiency Improvements, 1990 to 2008

Index (1990 = 1.00)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Estimated energy use without energy efficiency improvements	1.00	1.00	1.02	1.03	1.10	1.14	1.15	1.17	1.20	1.26	1.30	1.29	1.35	1.36	1.38	1.38	1.34	1.39	1.32
Actual energy use	1.00	0.99	0.99	1.00	1.05	1.08	1.10	1.10	1.09	1.12	1.15	1.11	1.17	1.20	1.22	1.20	1.16	1.26	1.19

Figure 1-17: Industrial Energy Use, With and Without Energy Efficiency Improvements (Without Upstream Mining), 1990 to 2008

Index (1990 = 1.00)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Estimated energy use without energy efficiency improvements	1.00	1.01	1.02	1.01	1.09	1.12	1.13	1.15	1.16	1.23	1.27	1.25	1.30	1.31	1.31	1.31	1.25	1.30	1.23
Actual energy use	1.00	0.99	0.98	0.96	1.02	1.04	1.05	1.05	1.04	1.05	1.09	1.04	1.09	1.09	1.12	1.07	1.02	1.08	1.01

Figure 1-18: Transportation Energy Use by Mode, 2008

	Energy use (PJ)	Percentage
Cars	648.5	
Passenger light trucks	440.1	
Motorcycles	4.1	
School buses	13.6	
Urban transit	31.6	
Inter-city buses	6.6	
Passenger air	249.6	
Passenger rail	2.8	
Passenger total	**1 396.9**	**53.8**
Freight light trucks	177.5	
Medium trucks	152.5	
Heavy trucks	571.3	
Freight air	5.1	
Freight rail	87.7	
Marine	100.4	
Freight total	**1 094.5**	**42.2**
Off-road total	**102.7**	**4.0**
Total transportation energy use	**2 594.1**	**100.0**

Figure 1-19: Market Shares of New Passenger Car and Light-Truck Sales, 1990 to 2008 (percentage)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Passenger car	74.2	74.8	72.3	69.3	66.9	64.8	62.5	59.5	58.9	60.8	62.9	63.4	62.7	62.2	61.7	61.7	61.2	59.6	61.4
Passenger light truck	25.8	25.2	27.7	30.7	33.1	35.2	37.5	40.5	41.1	39.2	37.1	36.6	37.3	37.8	38.3	38.3	38.8	40.4	38.6

Figure 1-20: Transportation Energy Use, Actual and Without Energy Efficiency Improvements, 1990 to 2008

Index (1990 = 1.00)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Estimated energy use without energy efficiency improvements	1.00	0.97	1.00	1.04	1.11	1.14	1.17	1.22	1.27	1.32	1.34	1.35	1.38	1.41	1.51	1.54	1.55	1.59	1.58
Actual energy use	1.00	0.96	0.99	1.00	1.05	1.07	1.09	1.13	1.17	1.20	1.22	1.21	1.23	1.26	1.31	1.33	1.33	1.38	1.38

Figure 1-21: Average Activity per Truck, 1990 to 2008 (tonne kilometres/truck)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Total medium-and heavy-duty truck vehicle activity	105 640	98 006	102 764	116 979	132 851	142 078	140 535	163 521	162 555	174 741	177 784	198 286	196 825	201 968	240 875	243 414	236 008	232 399	226 670

Figure 1-22: Trucking Energy Intensity, 1990 to 2008 (megajoules/tonne kilometre)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Total medium- and heavy-duty trucks energy intensity	3.74	3.77	3.77	3.61	3.40	3.47	3.40	3.32	3.16	3.01	3.03	2.83	2.80	2.92	2.60	2.64	2.73	2.84	2.96

Figure 2-1: Volume of Monthly Import Documents

Month	Paper	Electronic	Total
Apr. 10		135 957	135 957
May 10	6	138 486	138 492
June 10		146 391	146 391
July 10	3	148 370	148 373
Aug. 10	2	147 947	147 949
Sept. 10	1	151 731	151 732
Oct. 10	146	155 399	155 545
Nov. 10	146	145 062	145 208
Dec. 10	159	147 818	147 977
Jan. 11		137 174	137 174
Feb. 11		136 816	136 816
Mar. 11		164 150	164 150
Total	**463**	**1 755 301**	**1 755 764**

Figure 2-4: Distribution of ENERGY STAR Qualified Shipments of Appliances, 1999 to 2009

Appliance	1999 (%)	2000 (%)	2001 (%)	2002 (%)	2003 (%)	2004 (%)	2005 (%)	2006 (%)	2007 (%)	2008 (%)	2009 (%)
Dishwashers	0.6	1.6	9.7	29.8	56.5	81.0	90.8	79.7	76.2	89.3	89.5
Clothes washers	1.9	2.2	9.2	22.1	30.6	36.2	45.9	50.8	58.4	64.4	69.4
Refrigerators	..	..	11.4	22.3	40.7	34.2	37.6	37.3	44.3	53.4	53.4

Figure 2-5: ENERGY STAR Awareness Levels in Canada, 2010

	Percentage
Aware – non-aided	71
Aware – aided	72

Figure 3-1: Residential Energy Use and Energy Savings per Household, Pre-1945 to 2000–2009

	Pre-1945	1945–1959	1960–1969	1970–1979	1980–1989	1990–1999	2000–2009*	Average
Energy use pre-renovation (GJ)	271	200	187	174	174	163	149	193
Actual energy savings after renovations (GJ)	85	52	44	40	35	29	31	47

*data for 2007 are from ecoENERGY Retrofit – Homes (previous data source was EnerGuide for Houses).

Figure 3-2: Number of R-2000 Housing Certifications and ENERGY STAR Prescriptive-Labelled Houses, 1990 to 2010

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Number of R-2000 certified houses	495	699	1 196	1 299	784	610	416	484	265	213	319	329	428	379	583	500	439	483	557	508	411
Number of ENERGY STAR labelled houses (prescriptive path only)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	878	1 662	3 888	4 037	8 794

Figure 3-3: New Vehicle Fuel Efficiency Labelling

Year	On lot (%)	In showroom (%)
2007	78	56
2005	78	61
2001	77	56
1999	64	47

Figure 3-4: Company Average Fuel Consumption (CAFC) versus Canadian Voluntary Standards, 1990 to 2010*

Model year	Truck standard (L/100 km)	Trucks CAFC (L/100 km)	Car standard (L/100 km)	Cars CAFC (L/100 km)
1990	11.8	11.3	8.6	8.2
1991	11.6	11.4	8.6	8.0
1992	11.6	11.1	8.6	8.1
1993	11.5	11.3	8.6	8.1
1994	11.5	11.1	8.6	8.2
1995	11.4	11.5	8.6	7.9
1996	11.4	11.5	8.6	7.9
1997	11.4	11.3	8.6	8.0
1998	11.4	11.4	8.6	7.9
1999	11.4	11.3	8.6	7.9
2000	11.4	11.1	8.6	7.8
2001	11.4	11.0	8.6	7.8
2002	11.4	11.0	8.6	7.7
2003	11.4	10.8	8.6	7.6
2004	11.4	10.7	8.6	7.5
2005	11.2	10.5	8.6	7.4
2006	10.9	10.4	8.6	7.5
2007	10.6	10.1	8.6	7.2
2008	10.5	9.5	8.6	7.1
2009	10.2	9.1	8.6	6.8
2010	10.0	8.5	8.6	6.8

*2009 and 2010 data are estimates.

Figure 4-1: RETScreen Software: Cumulative Growth of User Base

Number of users	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Canada	1 421	2 966	4 527	6 650	9 754	14 125	18 178	24 005	28 990	36 891	44 987	54 152	60 553
World Total	3 109	8 748	14 365	21 942	30 253	41 877	56 448	80 437	107 205	147 155	193 033	242 775	276 693

Figure 5-1: Canadian Wind Power Capacity, 1993 to 2010

	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Wind power capacity (MW, cumulative)	1	22	23	23	24	27	127	139	215	233	326	445	686	1 459	1 846	2 369	3 319	4 124

Figure 5-2: Achievements Resulting From PPGTP Investments

	PPGTP Achievements (millions of GJ)
Renewable electricity	5.587246
Renewable thermal	3.242063
Energy efficiency	6.92412

Natural Resources Canada's Office of Energy Efficiency

Leading Canadians to Energy Efficiency at Home, at Work and on the Road

Canada

sources Ressources naturelles
Canada

Improving Energy Performance in Canada

Report to Parliament Under the *Energy Efficiency Act* For the Fiscal Year 2011–2012

Canada

Natural Resources Canada | Ressources naturelles Canada

Improving Energy Performance in Canada

Report to Parliament Under the *Energy Efficiency Act*
For the Fiscal Year 2011–2012

Canada

Publishing by the authority of the Minister of Natural Resources Canada
Government of Canada

Aussi disponible en français sous le titre : Améliorer le rendement énergétique au Canada – Rapport au Parlement en vertu de la *Loi sur l'efficacité énergétique* pour l'année financière 2011–2012

Cat. No. M141-10/2012E (Print)
ISSN 1491-0624

Cat. No. M141-10/2012E-PDF (On-line)
ISSN 1719-3478

To obtain additional copies of this or other free publications on energy efficiency, please contact:

Energy Publications
Office of Energy Efficiency
Natural Resources Canada
c/o St. Joseph Communications
Order Processing Unit
1165 Kenaston Street
PO Box 9809 Station T
Ottawa ON K1G 6S1
Tel.: 1-800-387-2000 (toll-free)
Fax: 613-740-3114
TTY: 613-996-4397 (teletype for the hearing-impaired)

You can also view or order most Office of Energy Efficiency publications on-line.
Visit our Virtual Library at oee.nrcan.gc.ca/publications. The Office of Energy Efficiency's Web site is at oee.nrcan.gc.ca.

Recycled paper

Table of Contents

FIGURES

TABLES

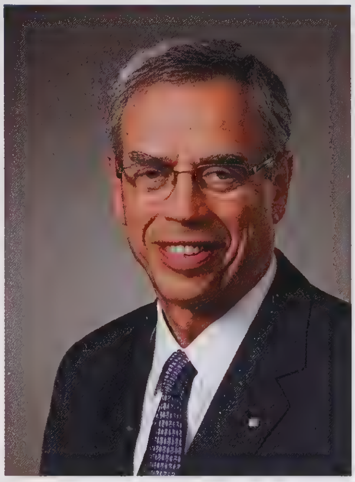
Minister's Foreword

I am pleased to introduce the 2011-2012 Report to Parliament on Improving Energy Performance in Canada.

Canada is quickly emerging as a global energy leader. As energy production booms, bringing opportunity, jobs and growth across the country, we must also think about energy use as this equally impacts Canadians and the economy. Energy efficiency presents enormous opportunities for Canada, saving Canadians money, stimulating economic growth and job creation, increasing productivity, competitiveness and exports. It also reduces greenhouse gas emissions, helping Canada to cost-effectively meet its emission reduction target of 17 percent below 2005 levels by 2020.

With this in mind, in September 2011, our Government renewed the ecoENERGY Efficiency program with an investment of $195 million over five years to help improve energy efficiency. Through this initiative, we are developing tools and practices to help Canadians become more energy efficient.

From 2007 to 2012, the ecoENERGY Retrofit–Homes program provided incentives to more than 640 000 homeowners. As a result of this program, these homeowners are now saving over $400 million on their annual energy bills and are lowering their energy consumption by an average of 20 percent. It is estimated that this program triggered more than $8 billion in economic activity and created or protected thousands of jobs during a period of global economic uncertainty. Natural Resources Canada continues to support home investments by providing information and advice through its ecoENERGY Efficiency for Housing initiative.



© Couvrette/Ottawa

In 2011-2012, Natural Resources Canada's Pulp and Paper Green Transformation Program supported 21 projects. As a result, the program has added nearly 200 megawatts of capacity to generate renewable electricity and is enabling mills to save 8.5 million gigajoules of energy annually. This is the equivalent to producing enough renewable thermal energy to continuously heat 70 000 homes.

Internationally, we are continuing to work with the United States, through the Clean Energy Dialogue, to enhance joint collaboration to accelerate the transition to a low-carbon economy, reduce greenhouse gases and combat climate change.

Moving forward, we will continue to implement measures to advance Canada's competitiveness, productivity and capacity for innovation by pursuing new and exciting developments in energy efficiency and technology to create jobs and build Canada's future economy.

The Honourable Joe Oliver, P.C., M.P.
Canada's Natural Resources Minister

Executive Summary

Gains in energy efficiency and the development of alternative transportation fuels and renewable energy have substantial benefits for society, the economy and the environment. Through its various programs, regulations and initiatives, Natural Resources Canada (NRCan) has been helping industry, individuals and governments across Canada to increase their energy efficiency and develop and deploy renewable and alternative energy sources as ways to reduce greenhouse gas emissions and improve the Canadian economy. Through gains in energy efficiency, Canadians have saved almost $27 billion in 2009 compared to energy use patterns in 1990.

Types of Energy Use

The two general types of energy use are primary and secondary. Primary use represents Canada's total energy consumption, including energy required to transform one energy form to another – such as coal to electricity – and energy required to deliver energy to consumers. Secondary use is energy consumed for residential, commercial/institutional, industrial, transportation and agricultural purposes.

Key facts in energy use include the following:

- Secondary energy use amounted to about 72 percent of primary energy use in 2009 (8541.6 petajoules [PJ]) and was responsible for 67 percent (463.9 megatonnes [Mt]) of total greenhouse gas emissions in Canada. This last figure includes emissions produced by utilities in meeting the demand for electricity.
- Canadians spent approximately $152 billion on secondary energy use in 2009.
- Due in part to the department's efforts, energy efficiency in Canada improved by 23.5 percent between 1990 and 2009. These efficiencies reduced energy use by approximately 1560 PJ and decreased greenhouse gas emissions by 81.1 Mt in 2009.

The industrial sector consumed the most energy, accounting for 37 percent of total secondary energy use in 2009. Transportation was second (30 percent), followed by residential (17 percent), commercial/institutional (14 percent) and agriculture (2 percent).

Promoting Energy Efficiency, Alternative Transportation Fuels and Renewable Energy

NRCan uses a broad range of policy instruments, including leadership; information; voluntary initiatives; financial incentives; research, development and demonstration; and regulation, to promote energy efficiency and the use of alternative fuels and renewable energy.

The *Energy Efficiency Act*, which came into force in 1992, gives the Government of Canada the authority to make and enforce regulations concerning minimum energy performance levels, labelling requirements and the collection of data on energy use for energy-using products and products that affect energy use. Thus far, prescribed standards and labelling requirements have been established for more than 40 products in Canada.

Launched in 2011–2012, the ecoENERGY Efficiency program is investing $195 million over five years to make the housing, building and equipment stock more energy-efficient, energy performance more

visible, and industry and vehicle operations more efficient. The program components are

- ecoENERGY Efficiency for Buildings
- ecoENERGY Efficiency for Housing
- ecoENERGY Efficiency for Equipment Standards and Labelling
- ecoENERGY Efficiency for Industry
- ecoENERGY Efficiency for Vehicles

Also in 2011–2012, the ecoENERGY for Alternative Fuels program received funding of $3 million over five years to encourage the use of alternative fuels through education and outreach, as well as through the development of codes and standards for natural gas.

In addition, NRCan invests in the research, development, and demonstration of new and emerging clean energy science and technology that produces economic, social and environmental benefits for Canadians.

The department oversees programs and initiatives that allocated more than $248 million in the 2011–2012 fiscal year to fund research on finding new, long-term, cleaner and more efficient solutions to reduce environmental emissions. With three laboratories across Canada, the department works with various sectors to develop and demonstrate energy-efficient alternative transportation fuel, renewable energy technologies and cleaner fossil fuels.

Canada is a global leader in the production of renewable energy. In 2010, renewable energy sources made up 17.1 percent of the primary energy supply and 62 percent of electricity generation and total electricity-generating capacity.

National and International Co-operation

NRCan partners with a variety of stakeholders, including provincial and territorial governments, municipal governments, industries, non-governmental organizations, as well as other countries and international organizations, to promote energy efficiency.

Provincial and territorial governments, utilities and non-government organizations use the federal energy efficiency, alternative transportation fuels and renewable energy program tools in their jurisdictions to complement their own energy efficiency programs. For example, 14 regional programs use the department's EnerGuide Rating System to measure home energy use. Seven Canadian jurisdictions also use it in their building code development, implementation or maintenance, and it has been used to develop the energy efficiency requirements for housing in the new National Building Code of Canada.

Municipal governments and agencies participate in the department's energy efficiency, alternative transportation fuels and renewable energy measures as clients and as partners and the department participates in ventures led by municipal organizations, such as the Green Municipal Fund.

Internationally, the department co-operates bilaterally with key partners such as the United States and with international organizations such as the International Energy Agency, the Asia-Pacific Economic Co-operation and the International Partnership for Energy Efficiency Co-operation, which Canada will chair from 2012 to 2014.

Selected Results

This report provides an overview of the work being done in each sector, highlights NRCan's initiatives and lists their key achievements for the 2011–2012 fiscal year, including the following:

- From 2007 to 2012, the ecoenergy Retrofit–Homes program provided incentives to more than 640 000 homeowners. As a result of this program, these homeowners are now saving over $400 million on their annual energy bills and are lowering their energy consumption by an average of 20 percent. It is estimated that this program triggered more than $8 billion in economic activity and created and protected thousands of jobs over that period.
- The ENERGY STAR® labelling initiative in Canada broadened its scope to include four new product

categories in 2011 and aligned with the United States to pilot an ENERGY STAR "Most Efficient" designation for the highest efficiency products in those categories.

- Projects funded under the Pulp and Paper Green Transformation Program added nearly 200 megawatts of renewable electrical capacity.
- CanmetENERGY's Drake Landing Solar Community project won Energy Globe Foundation's Energy Globe World Award for 2011. This project is the first large-scale, seasonal solar storage system in North America and the Globe World Award is a Canadian first.

A full list of the department's energy efficiency, alternative transportation fuels and renewable energy initiatives and expenditures appears in Appendix 1.

Introduction

NATURAL RESOURCES CANADA'S ENERGY EFFICIENCY, ALTERNATIVE TRANSPORTATION FUELS AND RENEWABLE ENERGY PROGRAMS

Energy Efficiency

Investing in energy efficiency can have substantial benefits for society, the economy and the environment. Energy efficiency saves Canadians and Canadian businesses money by decreasing their energy bills, stimulates the economy by creating local jobs and supports the environment by reducing greenhouse gas emissions, all of which lead to a greater quality of life for all Canadians. In addition, investing in energy efficiency can add to the global security of energy supplies by reducing the need for energy while strengthening Canada's energy security.

Due in part to the efforts of Natural Resources Canada (NRCan), energy efficiency in Canada improved by 23.5 percent between 1990 and 2009. In 2009 alone, the savings from energy efficiency improvements equalled the energy used to power more than 15.1 million homes for an entire year (not including transportation). It was the equivalent of eliminating the emissions produced by 26 million cars and passenger light trucks for a year. Overall, these energy efficiency gains saved Canadians almost $27 billion.[1]

With this in mind, the department partners with a variety of stakeholders such as provincial governments, non-profit organizations and the private sector to promote energy efficiency. The department's energy efficiency initiatives engage Canadian society and all major sectors of the economy in new and innovative approaches to reducing the consumption of energy in the residential, commercial/institutional, industrial and transportation sectors, to improve Canada's environment, its economy and its security.

Alternative Transportation Fuels

Energy use and greenhouse gas emissions from the transportation sector pose a challenge to the environment. The Government of Canada is committed to diversifying energy use in the transportation sector. It supports producing and using renewable transportation fuels such as ethanol and biodiesel, increasing alternative fuel stakeholder knowledge and developing codes and standards for natural gas. These initiatives can expand our energy mix and contribute to reducing greenhouse gas emissions while at the same time providing new opportunities for the agriculture sector.

Renewable Energy

Renewable energy is energy obtained from natural resources that can be replenished or renewed within a human lifespan, that is, the resource is a sustainable source of energy. Canada uses several of these types of resources such as moving water, wind, sunlight and plant biomass, which are not at risk of depletion when used for energy production.

Canada is a global leader in the production of renewable energy, particularly in hydroelectricity. As of December 31, 2010, 529 hydroelectric stations were operational across the country, totalling 75 104 megawatts (MW) of installed capacity, which contributed 59 percent of the nation's electricity production. Canada is the third largest hydroelectricity producer in the world, after China

[1] Natural Resources Canada, *Energy Efficiency Trends In Canada 1990–2009*, oee.nrcan.gc.ca/publications/statistics/trends11/pdf/trends.pdf.

and Brazil and the world's second largest net exporter of electricity after Paraguay.[2]

Other renewable energy sources are growing quickly. Wind power and solar photovoltaic are the fastest growing sources of electricity in Canada. As of December 31, 2011, there were 3094 wind turbines operational in 151 wind farms in all provinces and one territory, totalling 5265 MW of installed capacity that generated about 10 terawatt-hours or 1.8 percent of Canada's total electricity generation. In 2011, Canada ranked ninth in the world in terms of total installed wind power capacity and sixth in terms of new installations of wind turbines.

By the end of 2011, the solar photovoltaic industry added 204 MW of installed generating capacity for a total of 495 MW.

Until 2007, when it was surpassed by wind power, biomass was Canada's second renewable energy source for electricity generation, after hydropower, with approximately 1700 MW of installed capacity.

Also, Canada has one of the first large-scale tidal power facilities in the world, the 20-MW Annapolis Tidal Station in Nova Scotia.

Natural Resources Canada's Energy Efficiency, Alternative Transportation Fuels and Renewable Energy Initiatives

A complete list of NRCan's energy efficiency, alternative transportation fuels and renewable energy initiatives in 2011–2012 is provided in Appendix 1. These initiatives are managed by the following:

- the Office of Energy Efficiency (OEE), which delivers programming to improve energy efficiency and the use of alternative transportation fuels in all sectors of the Canadian economy
- CanmetENERGY, which delivers energy efficiency, alternative transportation fuels and renewable energy research, development and demonstration initiatives
- the Office of Energy Research and Development, which coordinates the department's energy research and development planning and fund allocations
- the Electricity Resources Branch, which develops federal policy in the area of renewable and electrical energy and delivers programs that support the deployment of renewable energy technologies
- the Policy, Economics and Industry branch of the Canadian Forest Service, which delivers funding for environmental improvements in pulp and paper mills and the commercialization of innovative technologies across the forest sector leading to non-traditional, high-value forest products and renewable energies
- the Science Branch of the Canadian Forest Service, which undertakes research and development on the sustainable use of forest biomass for energy
- CanmetMATERIALS, which develops innovative materials and processing technologies for applications in energy production and transportation and improved energy efficiency in the materials and transportation sectors
- CanmetMINING, which delivers research, development and demonstration initiatives to improve energy efficiency in the mining sector through the use of innovative mining and mineral processing equipment and systems

POLICY INSTRUMENTS

NRCan uses a variety of policy instruments in regard to energy supply and demand:

- regulation
- financial incentives
- leadership
- information
- voluntary initiatives
- research, development and demonstration

Regulation

The *Energy Efficiency Act* gives the Government of Canada the authority to make and enforce regulations that prescribe standards and labelling

[2] *Key World Energy Statistics*, pg 19 and 27, International Energy Agency, www.iea.org/publications/freepublications/publication/key_world_energy_stats-1.pdf.

requirements for energy-using products and products that affect energy use that are imported to Canada or shipped across provincial borders for lease or sale.

Financial Incentives

NRCan uses financial incentives to encourage end-users of energy to adopt energy efficiency and renewable energy technologies and practices. In 2011–2012, the department offered financial incentives for ethanol and biodiesel production, energy efficiency improvements for homes, efficiency and renewable energy production at pulp and paper mills, and the implementation of highly innovative technologies in the forest products sector.

Leadership

Leadership means setting an example for other levels of government and for the private sector by increasing energy efficiency and the use of alternative energy in the Government of Canada's operations.

Information

NRCan disseminates information to consumers by using methods ranging from broad distribution to individual consultations with clients. This practice increases awareness of the environmental impact of energy use and encourages consumers to become more energy-efficient and make greater use of alternative energy sources.

Information activities include publications, exhibits, advertising, conferences, Web sites, workshops, training, building-design software and promotional products.

Voluntary Initiatives

Companies and institutions work with NRCan voluntarily to set and achieve energy efficiency objectives. The department's voluntary energy efficiency, alternative transportation fuels and renewable energy initiatives target the commercial/institutional and industrial sectors and organizations whose products are major factors in energy use. The department works in collaboration with other government organizations, jurisdictions and the United States to develop model energy codes in the commercial/institutional building sector, as well as tools to assist building owners' and managers' decision making. The initiatives further involve industry-government agreements and, for groups of large industrial energy users, commitments to develop energy efficiency improvement targets and action plans. The department provides support to assist and stimulate action by companies and institutions on energy efficiency, including developing standards, educational material and training.

Research, Development and Demonstration

Ongoing improvement in energy efficiency is contingent on advancements and innovations in technology. NRCan's energy efficiency, alternative transportation fuels and renewable energy initiatives support the development and dissemination of more energy-efficient equipment, processes and technologies and alternative energy technologies. Research, development and demonstration also provides the scientific knowledge needed to develop the technologies, codes, standards and regulations required for the sustainable use of energy.

The department provides national leadership in energy science and technology by conducting research in its own laboratories and contracting research activities to other organizations. These initiatives are the only federal interdepartmental science and technology investment funds that focus on the energy sector and its economic and environmental effects.

FIGURE INT-1 Moving the Market

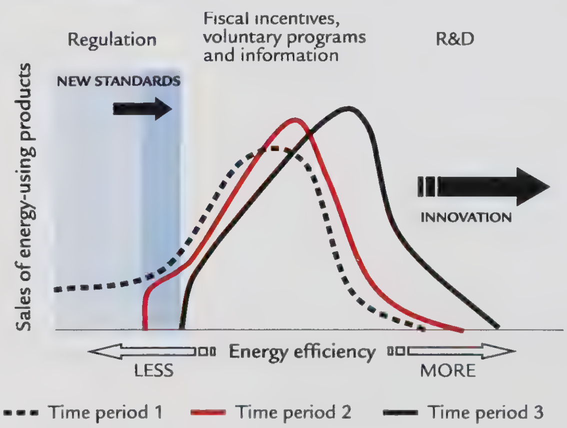


Figure INT-1 shows how these policy instruments work together to increase energy efficiency, that is, how they help to reduce the amount of energy required to complete a task or obtain a certain level of service. Energy performance regulations eliminate less efficient products from the market. Fiscal incentives, voluntary programs and information activities increase the number of people and organizations that take advantage of existing opportunities to use energy more efficiently. Research, development and demonstration increase the opportunities for achieving higher levels of efficiency in a particular type of energy use.

MEASURING PROGRESS

The primary goal of NRCan's energy efficiency, alternative transportation fuels and renewable energy initiatives is to change energy consumption patterns and thereby generate environmental and economic benefits. Part of assessing program progress and performance involves considering both program delivery and program effectiveness. The department monitors and tracks the following aspects of program delivery:

- program outputs
- program outcomes
- market outcomes

Program outputs are the items produced regularly, such as information and marketing materials, demonstration projects, financial incentives and regulations. Program outputs are designed to lead to **program outcomes** – namely, changes in the behaviour of groups targeted by a program. These groups may be either energy users or producers of energy-using equipment or structures. For example, program outcomes occur when consumers purchase more energy-efficient appliances than they would have if there were no program. Other important factors that influence consumer behaviour include product price, household income, personal taste and government and non-government programs.

Because program outcomes can directly affect the amount and type of energy consumed in the market, they contribute, in part, to observable **market outcomes**. Market outcomes ultimately reflect the impacts of the department's programs on changes in energy efficiency, energy intensity, greenhouse gas emissions and the use of alternative energy. In this sense, achievement of a targeted market outcome, or observable progress toward a market outcome, may be indicators of program effectiveness. Measuring progress toward an immediate market outcome can be difficult for research, development and demonstration programs, which typically take many years to produce results that can be properly assessed.

An example of a program outcome leading to a market outcome is a householder's purchase of a more energy-efficient appliance, resulting in reduced use of electricity. Depending on what source of electricity is involved and how the utility changes its electricity-generating methods to meet the change in demand resulting from reduced electricity use, this could also lead to a decline in greenhouse gas emissions.

DATA COLLECTION AND ANALYSIS

In 1991, NRCan launched the National Energy Use Database initiative to help the department improve its knowledge of energy consumption and energy efficiency at the end-use level in Canada and to support its analytical expertise. The database initiative plays several crucial roles directly related to the department's program activities. However, its most important role is to secure the development of a reliable, Canada-wide information base on energy consumption at the end-use level for all energy-consuming sectors.

The database initiative consists of several broad components that typically involve conducting large- and small-scale surveys of energy use in the transportation, industrial, commercial/institutional and residential sectors. These surveys gather information about energy-using equipment and buildings, measuring Canadians' energy use and monitoring the adoption of new technologies in the marketplace.

In July 2011, the department received preliminary data from the Survey of Commercial and Institutional Energy Use for reference year 2009. This represents the culmination of three years of work between NRCan's OEE and Statistics Canada. This survey combines the goals of two previously existing surveys: the Commercial and Institutional Consumption of Energy Survey and the Commercial and Institutional Building Energy Use Survey.

The survey collected both establishment-based and buildings-based data. The establishment-level data are used to inform energy specialists and consumers about recent energy consumption patterns in this sector of the Canadian economy. These data are also used in the OEE's energy efficiency model and energy trends analysis. The buildings-based data are used to build energy-intensity benchmarks for selected building types that will be included in the United States Environmental Protection Agency's ENERGY STAR Portfolio Manager benchmarking tool. The data will be used by the OEE in their work with the Environmental Protection Agency to adapt the benchmarking tool to meet Canadian needs. The Canadian adaptation of Portfolio Manager is a project that supports the Clean Energy Dialogue.

The database initiative also produces a comprehensive energy use database with accompanying publications to explain Canada's overall energy use and energy efficiency trends. All database initiative reports are available to the public, free of charge, both in hard copy and online at oee.nrcan.gc.ca/statistics.

INTERNATIONAL CO-OPERATION

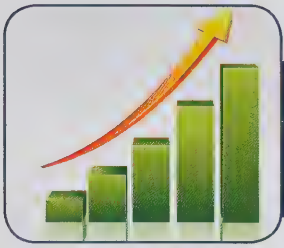
Continuing Canada's longstanding commitment to international co-operation and diplomacy, Canada participates in various international bodies regarding the supply and demand of energy. Such partnerships include the Asia-Pacific Economic Cooperation, the International Partnership for Energy Efficiency Cooperation, the Clean Energy Ministerial and the International Energy Agency. Through these and bilateral partnerships such as the U.S.-Canada Clean Energy Dialogue, Canada is a major player on the global energy stage.

IN THIS REPORT

This nineteenth annual *Report to Parliament* focuses principally on energy efficiency, alternative transportation fuels and renewable energy initiatives that address secondary energy use. Trends in energy use and greenhouse gas emissions in Canada for the residential, commercial/institutional, industrial, transportation and renewable energy sectors are discussed in Chapter 1.

Chapter 2 discusses equipment regulations under the *Energy Efficiency Act* and equipment-labelling activities. Chapter 3 describes the suite of ecoENERGY and related programs and lists key 2011–2012 achievements and overall program targets. Chapter 4 explains clean energy science and technology programs and achievements related to energy efficiency and the continued integration of renewable sources. Chapter 5 outlines NRCan's involvement with renewable energy sources and use. The sixth and final chapter describes domestic and international co-operation in energy efficiency, alternative transportation fuels and renewable energy.

Appendix 1 contains information about NRCan's energy efficiency, alternative transportation fuels and renewable energy expenditures. Appendix 2 contains detailed information about the figure data presented in this report. Calculations of the estimated greenhouse gas savings in this report (excluding direct reductions from the Pulp and Paper Green Transformation program) are based on Environment Canada's standardized emissions factors as described in its publication *Canada's Greenhouse Gas Inventory*. The emissions factor for electricity was based on the provincially weighted average of marginal fuel sources across the country.



CHAPTER 1

Trends in Energy Use

INTRODUCTION

Canada is a large country spanning more than 9.9 million square kilometres with a rugged geography and a harsh climate that requires significant amounts of energy to sustain day-to-day life and operate businesses. Fortunately, Canada is endowed with an abundance of energy from a variety of sources, which allows Canadians to respond to these challenges and profit from this comparative advantage in energy.

In spite of this relative energy abundance, Canadians understand the value of energy and can be proud of their progress in energy efficiency. Through gains in energy efficiency, Canadians have saved almost $27 billion in 2009 compared to energy use patterns in 1990. In 2009, approximately $152 billion was spent on energy to heat and cool homes and offices and to operate appliances, vehicles and industrial processes.

ENERGY USE AND GREENHOUSE GAS EMISSIONS

Energy has a variety of uses, which can be categorized into two general types: primary and secondary. Primary energy use includes the total requirements for all users of energy: the energy required to transform one energy form to another (e.g. coal to electricity) and the energy needed to transport energy supplies to the consumer. Secondary energy use is that used in final consumption for residential, commercial/institutional, industrial, transportation and agriculture needs. It is what turns on the light switches, runs the computers and operates the factories.

In 2009,[3] the amount of primary energy used in Canada was estimated at 11 897 petajoules[4] (PJ). Energy use has been increasing steadily over the decades as the population grows, homes get larger (and these larger homes are filled with more electronics) and more cars are purchased per household. However, in spite of this increase, the relative amount of energy required for each unit of output produced has decreased substantially.

DID YOU KNOW?

About one petajoule of energy is required to operate the Montréal Metro during one year.[5]

Secondary energy use made up approximately 72 percent of primary energy use in 2009, or 8541.6 PJ. It was also responsible for 67 percent (463.9 megatonnes [Mt]) of total greenhouse gas emissions in Canada, including indirect emissions – those produced by electric utilities to meet end-use electrical demand.

While secondary energy use increased by 23 percent from 1990 to 2009, Canada's population grew 22 percent and the gross domestic product increased by 57 percent. Thus energy use grew less rapidly than the economy as a whole, indicating a marked improvement in the energy intensity of our economy per unit of output. On the other hand, total energy use grew slightly faster than the population.

---

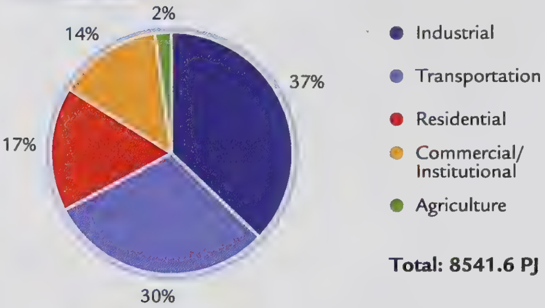
[3] Data in this chapter are presented for 1990–2009. Visit the Office of Energy Efficiency Web site to see data updates as they become available (oee.nrcan.gc.ca).

[4] One petajoule equals 1×10^{15} joules.

[5] 2001 data.

The share of secondary energy used by each major economic sector does not vary much from year to year. For 2009, as demonstrated in Figure 1-1, the industrial sector was the largest energy user, accounting for 37 percent of total secondary energy use. The transportation sector was the second largest energy user at 30 percent, followed by the residential sector at 17 percent, the commercial/institutional sector at 14 percent and the agricultural sector at 2 percent.

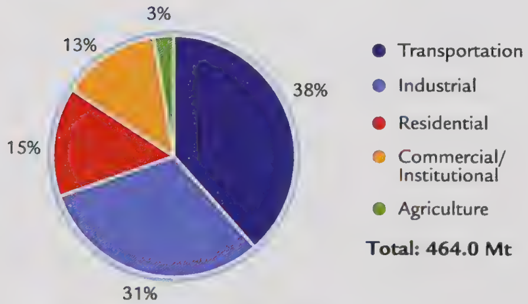
FIGURE 1-1 Secondary Energy Use by Sector, 2009



Source: oee.nrcan.gc.ca/corporate/statistics/neud/dpa/handbook_tables.cfm?attr=0

Figure 1-2 illustrates the distribution of greenhouse gas emissions by sector. This report deals with energy-related greenhouse gas emissions, which comprise carbon dioxide, methane and nitrous oxide. Carbon dioxide accounts for most of Canada's greenhouse gas emissions. All subsequent references in this report to carbon dioxide and greenhouse gas include emissions that are attributable directly to secondary energy use and emissions that are attributable indirectly to electricity generation, unless otherwise specified.

FIGURE 1-2 Greenhouse Gas Emissions From Secondary Energy Use by Sector, 2009



Source: oee.nrcan.gc.ca/corporate/statistics/neud/dpa/handbook_tables.cfm?attr=0

ENERGY INTENSITY AND ENERGY EFFICIENCY

The term "energy intensity" refers to the amount of energy use per unit of activity (gross domestic product). Energy intensity is sometimes used as a proxy for energy efficiency because it is a simple calculation for which data are readily available. However, this measure can be misleading because, in addition to pure energy efficiency, intensity captures the impact of other factors that influence energy demand, such as weather variations and changes in the structure of the economy.

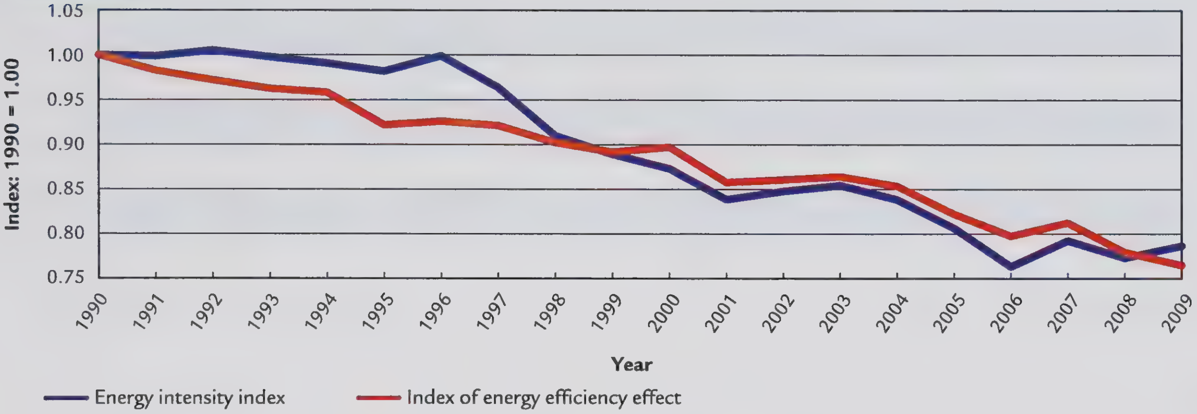
For example, of all the industrial processes, the production of aluminum (and alumina) is by far the most energy-intensive. To produce 1 tonne of aluminum requires almost 57 670 megajoules of energy (or 57 670 megawatt-hours of electricity). Other energy-intensive industries include petroleum refining, pulp and paper, iron and steel, cement, chemicals, smelting and refining and mining.

Energy efficiency refers to how effectively energy is being used for a given purpose. For example, providing a similar (or better) level of service with less energy consumption on a per-unit basis is considered an improvement in energy efficiency.

To properly gauge changes in energy efficiency over time, differences in economic structure and weather need to be removed from the intensity calculation. Natural Resources Canada's (NRCan's) Office of Energy Efficiency (OEE) applies an internationally recognized factorization analysis technique – the Log-Mean Divisia Index I methodology – to isolate the impact of energy efficiency on changes in Canadian energy use.

Figure 1-3 compares an index of annual variation in energy intensity with the OEE's index of energy efficiency, which tracks changes from 1990 to 2009. As illustrated, Canada's energy intensity and efficiency improved over this period. The reduction in energy intensity reflects an overall improvement in energy efficiency or how effectively energy is being used in producing one unit of gross domestic product. At the same time, the improvement in energy efficiency indicates how effectively energy is

FIGURE 1-3 Energy Intensity and the Energy Efficiency Effect, 1990 to 2009



Source: Natural Resources Canada, Residential, Commercial/Institutional, Transportation, Industrial End-Use Models, Ottawa, 2011.

being used to provide a certain level of service or output.

As illustrated in Figure 1-3, intensity underestimates the efficiency effect in Canada in the early 1990s and overestimates its impact in the latter part of the period. Before 1998, intensity improvements appear to be modest because colder weather (1992–1997) and a shift toward more energy-intensive industries (1990–1996) masked energy efficiency progress. In 2000, the intensity index dipped below the index for the energy efficiency effect. A switch to less energy-intensive industries, which began in the mid-1990s, combined with energy efficiency improvements accelerated the decline in energy intensity.

TRENDS IN ENERGY EFFICIENCY

NRCan regularly publishes *Energy Efficiency Trends in Canada*, which reports on changes in energy use and greenhouse gas emissions and the contributions of the following key factors to these changes (see Table 1-1):

- Increases in sector **activity** lead to increased energy use and greenhouse gas emissions. Activity is defined differently in each sector. For example, in the residential sector, it is defined as the number of households and the floor space of residences. In the industrial sector, it is defined as industrial gross domestic product, gross output and physical industrial output, such as tonnes of steel.
- Fluctuations in **weather** lead to changes in space-heating and space-cooling requirements. A colder winter or a warmer summer can lead to increased energy use.
- A shift in the **structure** of activity toward more energy-intensive components of activity leads to increased energy use and emissions. For example, if the distribution of activity in the industrial sector shifts from forestry to the iron and steel industry, industrial energy use will increase because the former sector is less energy intensive than the latter.
- **Service level** refers to the penetration rate of electrical devices and equipment, for example, the use of auxiliary equipment in commercial/institutional buildings and appliances in homes or the amount of floor space cooled.
- **Capacity utilization rate** refers to the proportion of the installed production capacity that is in use. In 2009, sectors such as mining, transportation, equipment, and iron and steel showed significant declines.
- **Energy efficiency effect** indicates how effectively energy is being used, for example, the degree to which less energy is being used to provide the same level of energy service. Energy efficiency gains occur primarily with improvements in technology or processes. An example of such an improvement would be replacing incandescent lights with compact fluorescent lamps.

TABLE 1-1 Explanation of Changes in Secondary Energy Use, 1990 to 2009

	Sectors					
	Residential	**Commercial/ institutional**	**Industrial**	**Transportation**	**Total***	**Change (%)**
1990 energy use (PJ)	1282.1	867.0	2710.0	1877.9	6936.1	
2009 energy use (PJ)	1422.3	1186.0	3168.4	2576.6	8541.6	
Change in energy use (PJ)	140.2	319.0	458.4	698.7	1605.5	23.1
Source: oee.nrcan.gc.ca/corporate/statistics/neud/dpa/handbook_tables.cfm?attr=0						
Explanatory factor (change due to)						
Activity	492.3	341.2	1181.5	720.7	2735.7	39.4
Weather	33.0	8.8	n/a	n/a	41.8	0.6
Structure	10.0	-0.9	-706.8	288.1	-409.6	-5.9
Service level	75.5	117.9	n/a	n/a	193.4	2.8
Capacity utilization			576.5		576.5	8.3
Energy efficiency	-470.6	-146.9	-592.8	-350.1	-1560.4	-22.5
Other factors					28.0	0.4

Source: oee.nrcan.gc.ca/corporate/statistics/neud/dpa/analysis_ca.cfm?attr=0
*Total also includes energy use for agriculture.

Capacity utilization in the industrial sector can have an impact on the efficient use of energy. In 2008 and 2009, this became noticeable as the downturn in the economy forced many processes to operate far below potential, using energy for limited production or to keep idle processes ready in case demand picked up. To allow for a meaningful measurement of the long-term trend in energy efficiency, the influence of capacity utilization was removed. The adjustment was made back to 1990 and had the effect of smoothing out the trend in energy efficiency progress.

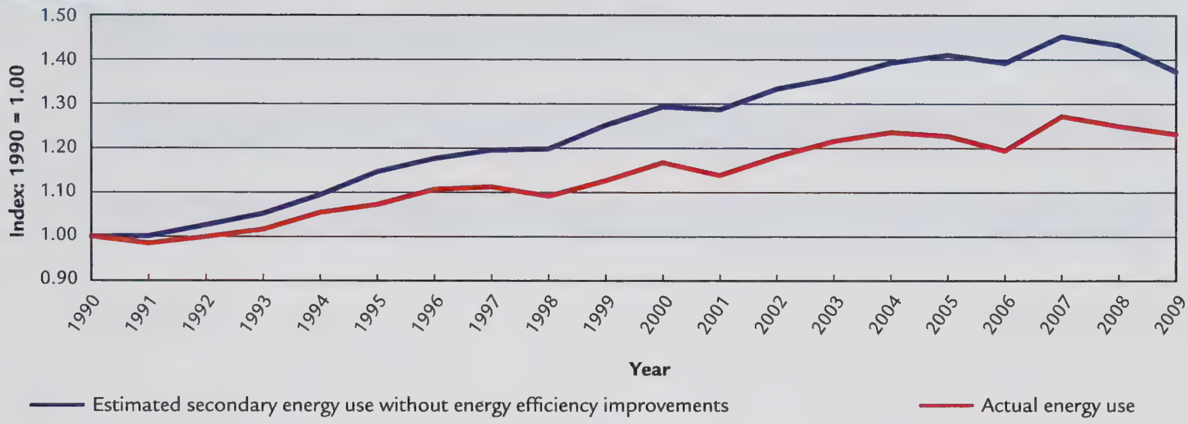
Consequently, in this chapter, energy efficiency is measured as the net result of total energy use minus the energy attributed to activity, weather, structure, service level and capacity utilization. However, other factors, such as individual consumer choice, may affect energy use and are not captured by the above standardized factors. The effects of activity, weather, structure, service level and capacity utilization may overstate or understate the "actual" change in energy use and energy efficiency improvements.

One of the greatest sources of untapped energy is the energy we waste. Energy efficiency in the Canadian economy is isolated and tracked in an effort to publicize this energy resource. This chapter examines all areas of the economy to determine what would have happened had there been no improvements and to identify, from the underlying data, areas that can continue to improve energy efficiency.

Energy efficiency has improved by 23.5 percent[6] since 1990. Without significant improvements in energy efficiency in end-use sectors, energy use would have actually increased 46 percent. These improvements reduced energy use by 1560 PJ, or the equivalent energy use of 26 million cars and passenger light trucks in 2009. This is estimated to have reduced greenhouse gas emissions by 81.1 Mt and saved Canadians $26.8 billion in 2009. The change in energy use between 1990 and 2009, actual and without energy efficiency improvements is shown in Figure 1-4.

[6] Based on the OEE index.

FIGURE 1-4 Secondary Energy Use, Actual and Without Energy Efficiency Improvements, 1990 to 2009



Source: oee.nrcan.gc.ca/corporate/statistics/neud/dpa/analysis_ca.cfm?attr=0

TRENDS IN RENEWABLE ENERGY

DID YOU KNOW?

Canada is a global leader in the generation of clean and renewable energy. We are the world's third largest producer of hydroelectricity, and more than three quarters of the electricity we generate produces no greenhouse gas emissions. Canada is also positioned first and ninth in the world for the installed capacity of solar air heating collectors and wind energy, respectively.

Canada is a leader in the production of renewable energy, with over 17.1 percent of its primary energy supply coming from renewable energy sources in 2010. Although renewable energy is often associated with electricity, renewable energy sources also produce thermal energy (heat) and transportation fuels. Renewable energy sources in Canada include inland and ocean water, wind, solar, geothermal and biomass.

Canada has a significant renewable electricity supply primarily due to the widespread use of hydroelectricity. In 2010, over 59 percent of Canada's electricity generation was provided by large and small hydroelectric plants, which generated 348 terawatt-hours (TWh) of electricity, down 4.6 percent from 365 TWh in 2009. Small hydro plants (i.e. less than 50 megawatts [MW]), representing an installed generating capacity of 3461 MW, provided about 2.7 percent of the total electricity generation in Canada.

In 2010, non-hydro renewable sources accounted for over 3 percent of Canada's electricity generation. In terms of annual additions to the installed capacity, wind energy is one of the fastest-growing sources of electricity in Canada. Its installed capacity increased from 139 MW in 2000 to 3967 MW in 2010 and to 5265 MW in 2011.

With almost 1700 MW of installed capacity in 2010, biomass (waste and virgin biomass and landfill gas) remains one of the main non-hydro renewable energy sources in Canada.

Solar photovoltaic energy also experienced high rates of capacity growth – about 45 percent average rate of growth annually between 1999 and 2011. So far, 2011 has been the best year for solar photovoltaic, with 204 MW of new installations for a total solar photovoltaic installed capacity in Canada of 495 MW.

The Canadian active, solar thermal, installed capacity in 2011 was 1 184 830 square metres (m^2), which is approximately 820 megawatts thermal (MW_{th}). The domestic market increase has averaged over 20 percent annually since 1998. In 2011, the solar thermal collector market in Canada was

approximately 163 435 m^2, approximately 18 percent fewer installations than in 2010 (199 490 m^2).

British Columbia and Nova Scotia are taking steps to support the development of the next generation of ocean renewable energy technologies, which use waves, ocean currents and tides to generate electricity.

In 2010, the Fundy Ocean Resource Centre for Energy, a technology demonstration facility, started testing three technologies with a total capacity of 4 MW. Wave and tidal-current technologies are also being tested off the coast of British Columbia, and a commercial facility for generating electricity may be feasible within the next decade.

In 2010, approximately 11 265 ground-source heat pump units were installed in Canada. This is roughly 28 percent less than the 15 640 units installed in 2009. As of December 31, 2010, there were more than 95 000 units in operation in Canada, representing approximately 1045 MW_{th} of installed capacity and producing an estimated 1420 gigawatt-hours equivalent annually.

As described in Chapter 5, in 2011–2012, NRCan carried out three renewable energy initiatives:

- Pulp and Paper Green Transformation Program – to increase energy efficiency and the production of renewable energy in Canadian pulp an paper mills
- Marine Renewable Energy Enabling Measures Program – to support the administering of marine renewable energy activity in the federal offshore
- Investments in Forest Industry Transformation program – which supports projects that promote innovative technologies in the forest sector (alternative energy systems could qualify for funding from this program)

TRENDS IN RESIDENTIAL SECTOR

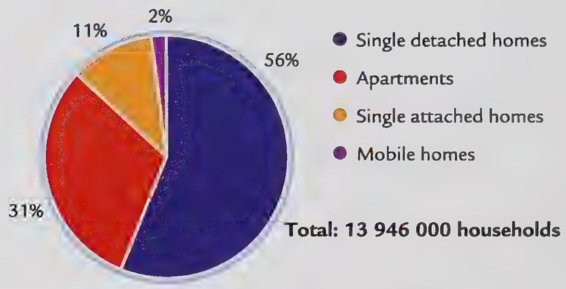
Energy Use and Greenhouse Gas Emissions

The residential sector includes four major types of dwellings: single detached, single attached, apartments and mobile homes. Energy is used in dwellings for space heating and cooling; water heating; and the operation of appliances, electronic equipment and lighting.

Canadians spent $26.8 billion on household energy needs in 2009. This sector accounted for 17 percent (1422.3 PJ) of secondary energy use and 15 percent (67.9 Mt) of greenhouse gases emitted in Canada.

The choices Canadians made with respect to their living space also factors into the amount of energy consumed in this sector. Average living space in 2009 was 11 percent higher than in 1990, while the number of individuals per household fell to 2.5 (from 2.8 in 1990). Furthermore, most dwellings in Canada are single detached houses. The next largest type of dwelling is apartments, followed by single attached dwellings and mobile homes (see Figure 1-5). In 2011–2012, the OEE's ecoENERGY Retrofit – Homes and ecoENERGY Efficiency for Housing programs aimed to improve the energy efficiency of single detached and attached houses.

FIGURE 1-5 Canadian Housing Stock by Building Type, 2009



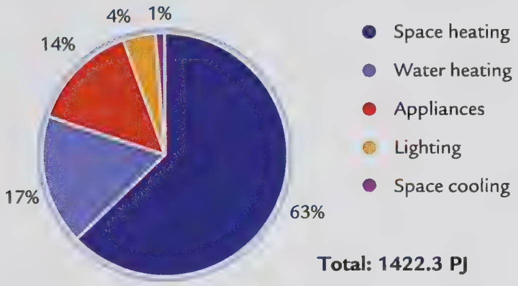
Source: oee.nrcan.gc.ca/corporate/statistics/neud/dpa/handbook_res_ca.cfm?attr=0

Between 1990 and 2009, residential energy use increased by 11 percent, or 140.2 PJ. Much of this increase is due to a rise in the number of households, combined with increased average living space and higher penetration rate of appliances. But as homeowners gradually switched to cleaner energy sources to heat their homes (less greenhouse gas-intensive fuels), the associated greenhouse gas emissions actually fell by 0.8 percent during the same period.

Energy intensity (gigajoules/household) decreased 18 percent despite the average household operating more appliances, becoming larger and increasing

its use of space cooling. Space and water heating constituted 80 percent of residential energy use (which exhibited a small drop in space-heating energy use), followed by operating appliances, lighting and space cooling (see Figure 1-6).

FIGURE 1-6 Residential Energy Use by End Use, 2009



Source: oee.nrcan.gc.ca/corporate/statistics/neud/dpa/handbook_res_ca.cfm?attr=0

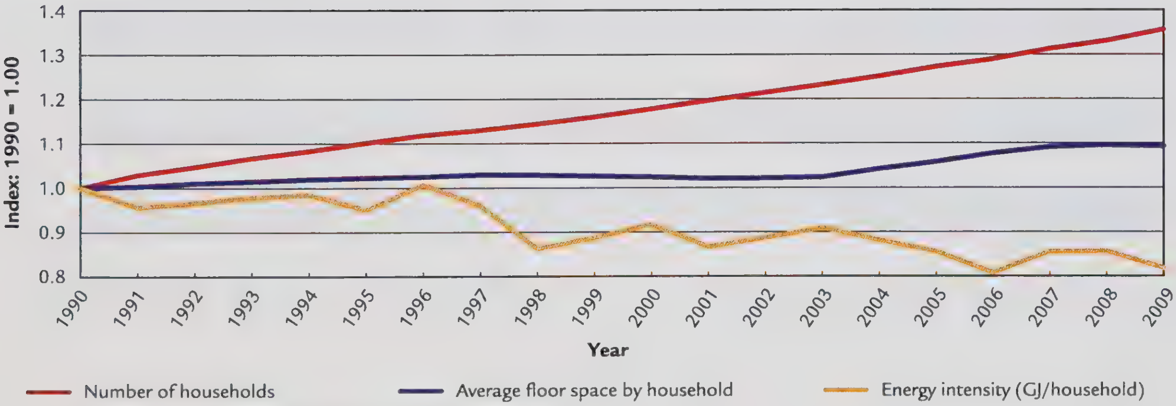
Five main factors influenced residential energy use between 1990 and 2009 – activity, weather, structure, service level and energy efficiency effect:

- Activity – As measured by combining a mix of households and floor space, energy use increased 38 percent (492.3 PJ). Growth in activity was driven by a 48 percent increase in floor area and by a rise of 36 percent in the number of households.
- Weather – In 2009, both the winter and summer were cooler than in 1990. The net result was an overall increase in energy demand of 33.0 PJ.
- Structure – The increase in the relative share of single family houses resulted in the sector using an additional 10.0 PJ of energy.
- Service level – The increased penetration rate of appliances and the increased floor space cooled by space cooling units were responsible for 75.5 PJ of the increase in energy.
- Energy efficiency – Improvements to the thermal envelope of houses and to the efficiency of residential appliances and space-and water-heating equipment led to an overall energy efficiency gain in the residential sector. This efficiency gain saved 470.6 PJ of energy.

Growth in residential energy use was driven in large part by growth in activity. This growth in activity – specifically, growth in total floor space and number of households – was due to the increase in the average size of newly constructed houses, the rising population and the trend toward fewer individuals per household (see Figure 1-7).

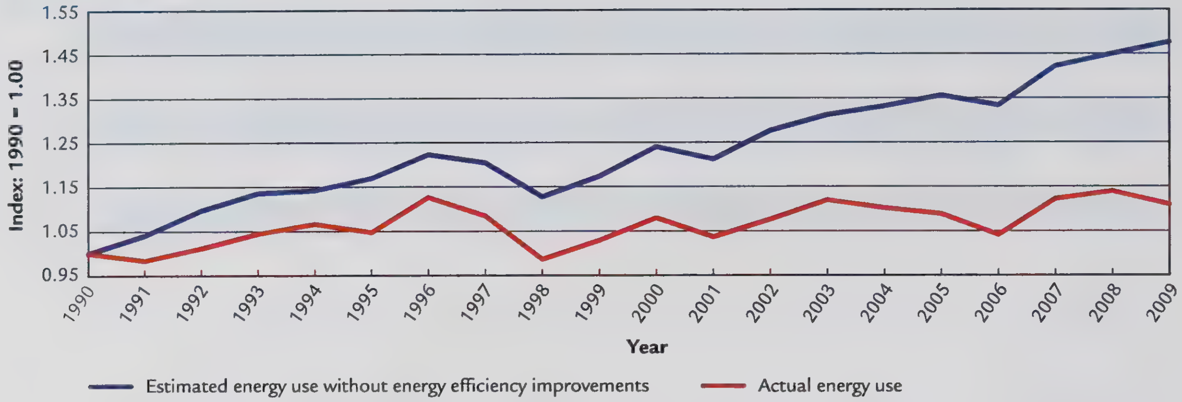
These increases were partially offset by significant improvements in energy efficiency. Service level increased energy demand because more Canadians warmed their homes during the winter months in 2009 than in 1990, and Canadians operated more appliances in 2009 than they did in 1990.

FIGURE 1-7 Number of Households, Average Floor Space by Household and Energy Intensity Indexes, 1990 to 2009



Source: oee.nrcan.gc.ca/corporate/statistics/neud/dpa/analysis_ca.cfm?attr=0

FIGURE 1-8 Residential Energy Use, Actual and Without Energy Efficiency Improvements, 1990 to 2009



Source: Natural Resources Canada, Residential End-Use Model, Ottawa, 2011.

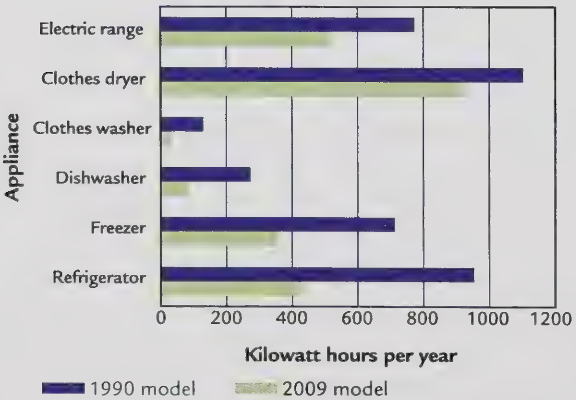
Energy Efficiency

The change in residential energy use between 1990 and 2009 and the estimated energy savings due to energy efficiency measures are shown in Figure 1-8.

Overall, energy efficiency upgrades – including improvements to the thermal envelope (insulations, windows, etc.) and more energy-efficient appliances, furnaces and lighting – resulted in significant monetary savings for each Canadian household. The 37 percent improvement in energy efficiency between 1990 and 2009 translated into $8.9 billion (or 470.6 PJ) in energy savings in 2009.

Figure 1-9 shows how average energy consumption of new appliances has improved, by comparing 1990 and 2009 models.

FIGURE 1-9 Average Energy Consumption of New Electric Appliances, 1990 and 2009 Models



Source: oee.nrcan.gc.ca/corporate/statistics/neud/dpa/tableshandbook2/res_00_16_e_5.cfm?attr=0.

DID YOU KNOW?

The 470.6 PJ of energy efficiency savings in the residential sector translates into an average savings of $660 per Canadian household in 2009.

In 2011–2012, NRCan carried out the following initiatives to increase energy efficiency in the residential sector:

- ecoENERGY Retrofit – Homes
- ecoENERGY Efficiency for Housing
- ecoENERGY Efficiency for Equipment Standards and Labelling
- Clean Energy Systems for Buildings and Communities

TRENDS IN COMMERCIAL/ INSTITUTIONAL SECTOR

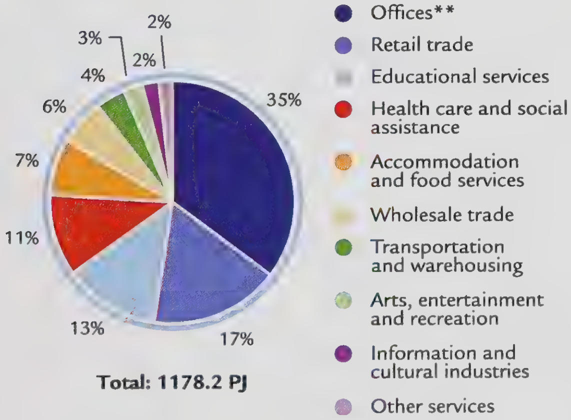
Energy Use and Greenhouse Gas Emissions

The commercial/institutional sector includes activity related to trade, finance, real estate, public administration, education and commercial services. This sector uses energy mainly for space and water heating, space cooling and lighting, as well as operating auxiliary equipment (such as computers) and motors.

In 2009, commercial business owners and institutions spent $24 billion on energy to provide services to Canadians. This represented about 3 percent of the value of the gross domestic product related to the sector. The sector also accounted for 14 percent of total energy use in Canada and produced 13 percent of associated greenhouse gas emissions.

Between 1990 and 2009, commercial/institutional energy use (including street lighting) increased by 37 percent, from 867.0 PJ to 1186.0 PJ. Greenhouse gas emissions from the sector rose by 37 percent in the same period. However, between 2008 and 2009, greenhouse gas emissions including electricity-related emissions decreased by 5 percent. A combination of factors led to this change: a marked reduction in the emission factor related to electricity generation, which was caused by a significant decrease in coal input used to generate electricity in 2009 and an overall decrease in electricity consumption, especially in Ontario, where total energy consumption fell by 6 percent in 2009 and electricity consumption alone fell by 10 percent. This change was mainly attributable to a decrease in space cooling (summer in 2009 was cooler than in 2008).

FIGURE 1-10 Commercial/institutional Energy Use by Activity Type*, 2009



*Excludes street lighting

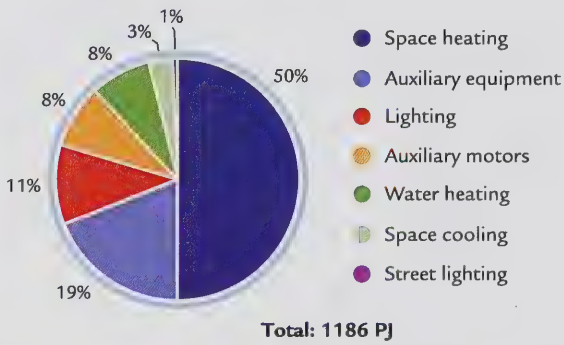
**Offices includes activities related to finance and insurance; real estate and rental and leasing; professional, scientific and technical services; and public administration.

Source: oee.nrcan.gc.ca/corporate/statistics/neud/dpa/tableshandbook2/com_00_1_e_5.cfm?attr=0

To highlight energy use in commercial/institutional activities, the following analysis excludes energy use for street lighting. The commercial/institutional sector comprises many activity types (see Figure 1-10). In 2009, offices accounted for 41 percent of the sector's energy demand. Retail trade (16 percent) and educational services (13 percent) were the next largest users.

Energy is used for seven purposes in commercial/institutional activities. As illustrated in Figure 1-11, in 2009, the largest of these was space heating, which accounted for 50 percent of the energy use in the sector. Two other end uses have shown large increases in energy requirements: auxiliary equipment, resulting from increasing computerization of work spaces and space cooling, resulting from the higher cooling rate of commercial/institutional buildings.

FIGURE 1-11 Commercial/institutional Energy Use by Purpose, 2009



Source:oee.nrcan.gc.ca/corporate/statistics/neud/dpa/tableshandbook2/com_00_1_e_5.cfm?attr=0

Five main factors influenced commercial/institutional energy use between 1990 and 2009 – activity, weather, structure, service level and energy efficiency effect:

- Activity – A 39 percent increase in floor space led to a 40 percent (341.2 PJ) growth in energy use and an increase of 17.5 Mt in greenhouse gas emissions.
- Structure – The effect of structure changes in the sector (the mix of activity types) was small

and therefore changed greenhouse gas-related emissions only marginally.

- Weather – In 2009, both the winter and summer were cooler than in 1990. The net result was an 8.8-PJ increase in energy demand in the commercial/institutional sector, mainly for space heating, which had the effect of increasing greenhouse gas emissions by 0.5 Mt.
- Service level – An increase in space cooling and in the service level of auxiliary equipment, which is the penetration rate of office equipment (e.g. computers, fax machines and photocopiers), led to a 111.5-PJ increase in energy use and a 6.0-Mt increase in greenhouse gas emissions.
- Energy efficiency – Improvements in the energy efficiency of the commercial/institutional sector saved 103.6 PJ of energy and 5.6 Mt of related emissions.

Energy Efficiency

Many of the energy efficiency improvements in the commercial/institutional sector are similar to those in the residential sector. They include improvements to the thermal envelope of buildings (insulation, windows, etc.) and increased efficiency of energy-consuming items, such as furnaces, auxiliary equipment and lighting, which slowed the rate of increase in energy use. Without improvements in energy efficiency, energy use in the commercial/institutional sector would have increased by 54 percent. However, actual energy use increased by only 37 percent between 1990 and 2009, resulting in energy savings of $3.0 billion in 2009 (see Figure 1-12).

Between 1990 and 2009, the estimated energy efficiency improvements resulted in energy savings of 147 PJ for this sector.

In 2011–2012, NRCan carried out the following initiatives to increase energy efficiency in the commercial/institutional sector:

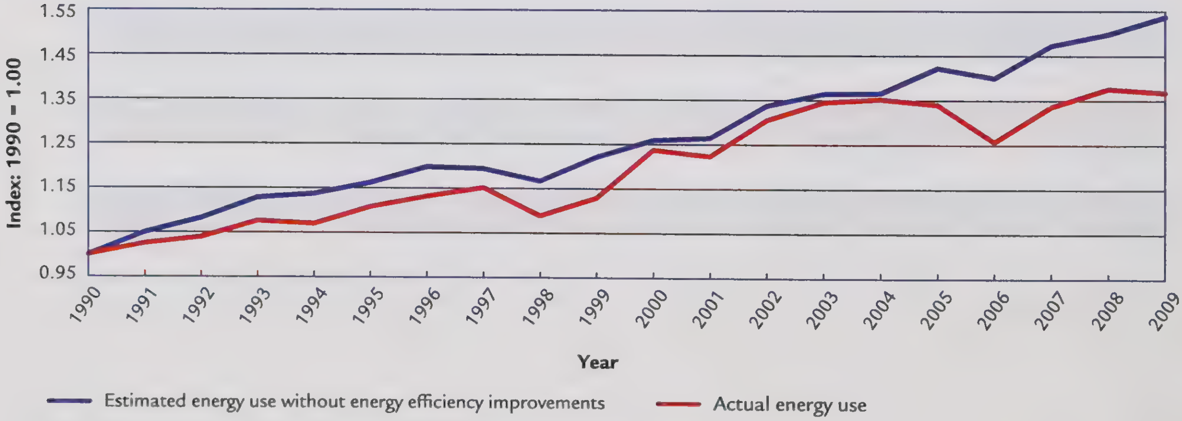
- ecoENERGY Efficiency for Buildings
- ecoENERGY Efficiency for Equipment Standards and Labelling
- Clean Energy Systems for Buildings and Communities

TRENDS IN INDUSTRIAL SECTOR

Energy Use and Greenhouse Gas Emissions

The industrial sector includes all manufacturing, mining (including oil and gas extraction), forestry and construction activities. However, it excludes electricity generation. This sector uses energy in industrial processes as a source of motive power and to produce heat or generate steam. This sector alone spent $33.3 billion on energy in 2009.

FIGURE 1-12 Commercial/institutional Energy Use, Actual and Without Energy Efficiency Improvements, 1990 to 2009



Source: Natural Resources Canada, Commercial/Institutional End-Use Model, Ottawa, 2011.

Overall, industrial energy demand in 2009 accounted for 37 percent (3168.4 PJ) of secondary energy use and 31 percent (144.5 Mt) of greenhouse gas emissions (including electricity-related emissions). Between 1990 and 2009, actual industrial energy use increased by 17 percent, from 2710.0 PJ to 3168.4 PJ. The associated end-use greenhouse gases increased 8 percent, from 134.3 Mt to 144.5 Mt.

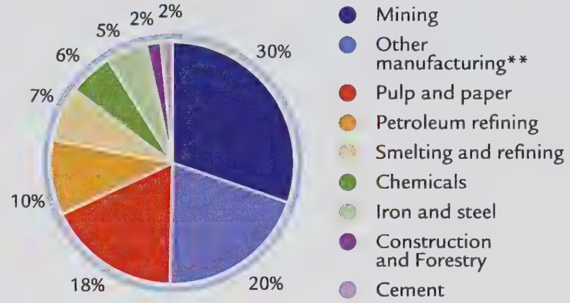
Energy use and greenhouse gas emissions decreased in 2009 compared with 2008. This change was caused by the downturn in economic activity which spanned the last half of 2008 and the first half of 2009.

Furthermore, energy intensity grew by 12 percent in 2009 while industries operated at only 68.6 percent of capacity, a drop of 8.4 percent from 2008. To illustrate the effect, capacity utilization was included in the factorization process of Canadian industry. The mining, transportation equipment and iron and steel industries exhibited significant declines in capacity utilization.

In the industrial sector, energy is used primarily to produce heat, generate steam or as a source of motive power. For example, coal is used by the cement industry to heat kilns. Numerous other industries use natural gas to fuel boilers for steam generation and electricity to power motors for pumps and fans. In 2009, energy was consumed primarily in mining, other manufacturing, pulp and paper production, and the petroleum refining industries. Mining alone accounted for 30.3 percent of total industrial energy demand (see Figure 1-13).

The cost of energy in production processes can vary significantly by industry. Generally, energy purchases account for only a small portion of total expenditures. However, for some relatively energy-intensive industries – such as cement, aluminum, pulp and paper, and iron and steel – this share was 10 percent or higher in 2009 (Figure 1-14). For cement, in particular, the share was 22.5 percent.

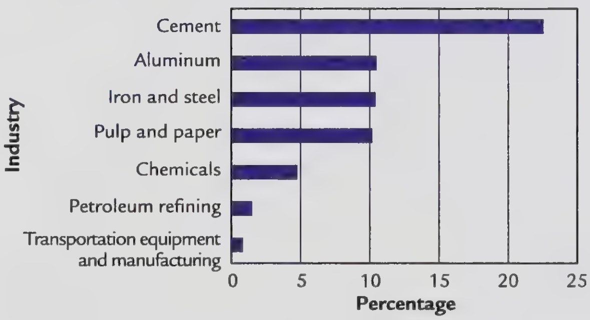
FIGURE 1-13 Industrial Energy Use by Subsector – Including Electricity-related Emissions*, 2009



*The subsectors reflect the current definitions in the *Report on Energy Supply and Demand in Canada*.
**Other manufacturing comprises more than 20 manufacturing industries.
Source: oee.nrcan.gc.ca/corporate/statistics/neud/dpa/trends_agg_ca.cfm

Between 1990 and 2009 industrial greenhouse gas emissions, including electricity-related emissions, increased by only 8 percent. In fact, emission levels fell back to their 1997 level of 144 Mt. Much of the drop in greenhouse gas emissions was because of lower levels of activity in 2009.

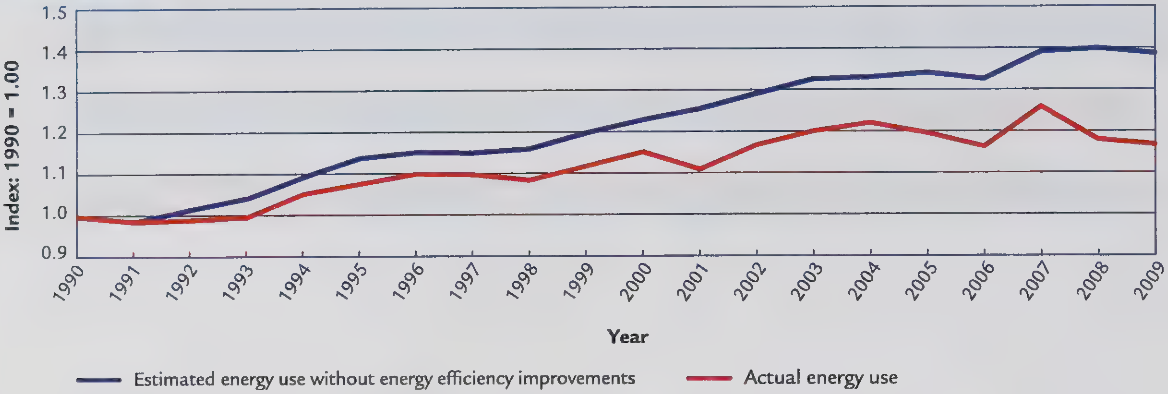
FIGURE 1-14 Cost of Energy to Manufacturing Industries as a Percentage of Total Production Cost, 2009



Source: Statistics Canada, CANSIM Table 301-0006.

As the Canadian economy evolves, so does the industrial make-up of greenhouse gas emissions. Increased production in the oil and gas industries has caused a larger share of direct greenhouse gas emissions for that industry, while other energy-intensive industries, such as pulp and paper, have reoriented operations and restructured to meet international competition resulting in a 60 percent decrease in greenhouse gas emissions and a smaller share of overall emissions.

FIGURE 1-15 Industrial Energy Use, Actual and Without Energy Efficiency Improvements, 1990 to 2009



Source: Natural Resources Canada, Industrial End-Use Model, Ottawa, 2011.

Four main factors influenced industrial energy use between 1990 and 2009 – activity, structure, capacity utilization and energy efficiency effect:

- Activity – The mix of gross domestic product, gross output and production units (activity measures) increased energy use by 44 percent, or 1181.5 PJ.
- Structure – The structural changes in the industrial sector, specifically a relative decrease in the activity share of energy-intensive industries, helped the sector to reduce its energy use by 706.8 PJ.
- Capacity utilization – The capacity utilization effect increased industrial energy use by 576.5 PJ.
- Energy efficiency – Improvements in the energy efficiency of the industrial sector avoided 592.8 PJ of energy use and 27.0 Mt of greenhouse gas emissions.

Energy Efficiency

In 2009, Canadian industry saved $6.2 billion in energy costs because of energy efficiency improvements, or 592.8 PJ of energy. This translates into 27.0 Mt of avoided greenhouse gas emissions. The change in energy use between 1990 and 2009 and the estimated energy savings attributed to energy efficiency are shown in Figure 1-15.

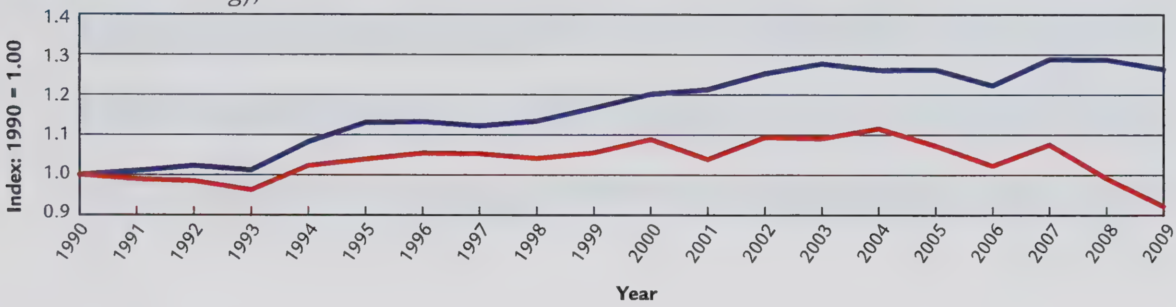
Energy efficiency improvements in the form of more efficient capital and management practices are important factors in managing energy use and decreasing energy intensity. Since 1990, energy efficiency in the industrial sector has improved 10 percent, largely because of improvements in energy intensity. However, the 2009 analysis also incorporated an assessment of the influence of variation in capacity utilization. If capacity utilization were factored out of the analysis, manufacturing energy efficiency savings actually grows to 688.5 PJ in 2009.

The energy savings made by some industries because of the energy efficiency improvements were offset by increases in consumption by the upstream mining, industrial gas and petrochemical subsectors.

From 1990 to 2009, the upstream mining share of industrial energy use grew from 8 percent to 27 percent. This change reflects not only growth in production but also a shift from conventional to the significantly more energy-intensive, unconventional oil production. To provide a clearer assessment of efficiency gains in the rest of the industry, the factorization analysis was produced without the upstream mining sector and with capacity utilization factored out. Without upstream mining, Canadian industries improved energy efficiency by 35 percent, or avoided using 881.5 PJ of energy (see Figure 1-16).

In 2011–2012, NRCan carried out the following initiatives to increase energy efficiency in the industrial sector:

FIGURE 1-16 Industrial Energy Use, With and Without Energy Efficiency Improvements (Without Upstream Mining), 1990 to 2009



Source: Natural Resources Canada, Industrial End-Use Model, Ottawa, 2011.

- ecoENERGY Efficiency for Industry
- ecoENERGY Efficiency for Equipment Standards and Labelling
- Clean Energy Systems for Industry

TRENDS IN TRANSPORTATION

Energy Use and Greenhouse Gas Emissions

Canada's transportation sector is diverse and is responsible for moving people and goods over immense distances, varied geography and often intense weather conditions. Consequently, transportation has the largest energy bill of any sector in 2009. Although the sector (individuals and companies) spent $63.4 billion on energy (90 percent more than the second-place industrial sector), it actually uses only 30 percent of total energy in Canada (37 percent for the industrial sector). The large energy bill is due to the notably higher cost of transportation fuels compared to the prices of energy used in other sectors. The transportation sector includes road, air, rail and marine transport.

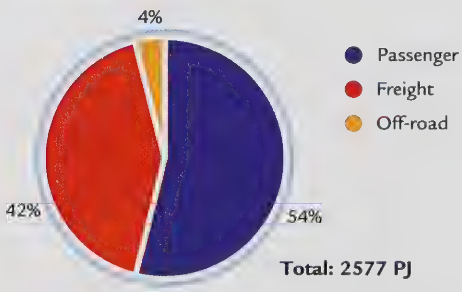
The transportation sector used 2576.6 PJ of energy in 2009 (a 1 percent decrease from 2008) and accounted for the largest portion of Canadian end-use greenhouse gas emissions at 38 percent (178.3 Mt). Much of the decrease in transportation energy use in 2009 occurred in marine and heavy truck transport and can be associated with a decline in economic activity.

DID YOU KNOW?

According to the *IEA Scoreboard 2011 – Implementing energy efficiency policy: Progress and challenges in IEA member countries*, Canada had the highest proportion of air travel in 2008, as measured by passenger-kilometres, amongst the International Energy Agency member countries.

The transportation sector consists of three subsectors: passenger, freight and off-road. In 2009, passenger modes consumed more than half (54 percent) of total transportation energy use, while freight transportation accounted for 42 percent; off-road represented only 4 percent (see Figure 1-17).

FIGURE 1-17 Transportation Energy Use by Mode, 2009



Source: oee.nrcan.gc.ca/corporate/statistics/neud/dpa/tablestrends2/tran_ca_7_e_4.cfm?attr=0

The passenger subsector has three modes: road, rail and air. The freight subsector, as defined by NRCan, is composed of road, rail, air and marine modes. All of NRCan's transportation energy use programs focus on the energy used in road transportation. Between 1990 and 2009, total transportation energy use increased by 37 percent, from 1877.9 PJ to 2576.6 PJ, and the associated greenhouse gas emissions rose 36 percent, to 178.3 Mt from 131.4 Mt.

Within the transportation sector, freight was by far the fastest growing subsector, accounting for 62 percent of the change in total transportation energy use. Most of this increase was attributable to the increased use of heavy trucks, which are more energy-intensive than other modes. Passenger transportation energy use increased by 19 percent (226.8 PJ), while freight transportation energy use increased by 67 percent (432.0 PJ).

Three main factors influenced passenger transportation energy use between 1990 and 2009 – activity, structure and energy efficiency effect:

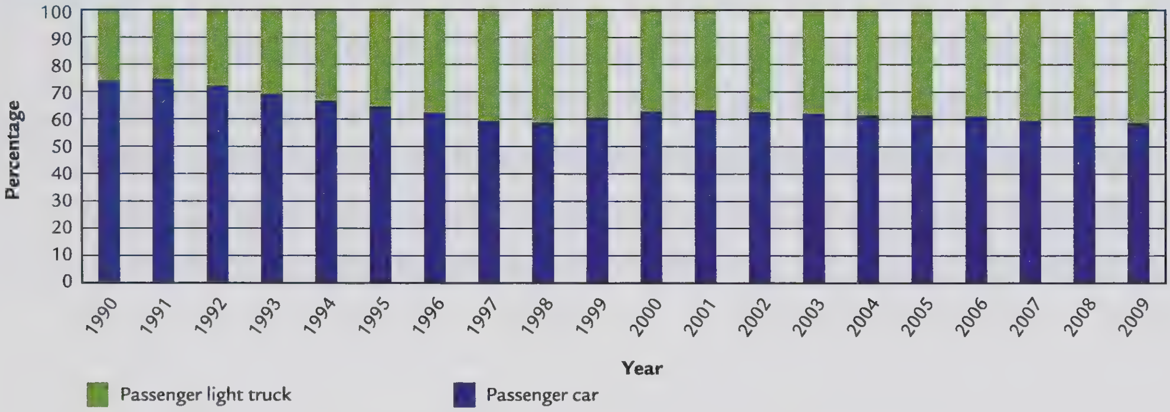
- Activity – The activity effect (i.e. passenger-kilometres travelled) increased energy use by 45 percent, or 457.5 PJ, with a corresponding 31.1-Mt increase in greenhouse gas emissions. Light truck and air transportation led the growth in passenger-kilometres (and therefore, activity effect), with respective increases of 161 percent and 84 percent.
- Structure – Changes to the mix of transportation modes, or the relative share of passenger-kilometres travelled by air, rail and road, are used to measure changes in structure. The popularity of minivans and sport utility vehicles increased the activity share of light trucks compared with other modes, contributing to a 32.4-PJ increase in energy consumption and a 2.2-Mt increase in greenhouse gas emissions.
- Energy efficiency – Improvements in the energy efficiency of passenger transportation saved 263.3 PJ of energy and 17.9 Mt of energy-related greenhouse gas emissions. The light-duty vehicle segment (cars, light trucks and motorcycles) of passenger transportation represented 73 percent of these energy savings.

Three main factors influenced freight transportation energy use between 1990 and 2009 – activity, structure and energy efficiency effect:

- Activity – The activity effect (i.e. tonne-kilometres moved) increased energy use 41 percent, or 263.2 PJ, and caused a corresponding 18.7-Mt increase in greenhouse gas emissions. This increase in the number of tonne-kilometres was mainly due to an increase of 173 percent in heavy-trucks activity and an increase of 41 percent in medium-trucks activity.
- Structure – Changes to the mix of transportation modes – or the relative share of tonne-kilometres travelled by air, marine, rail and road – are used to measure changes in structure. For example, an overall change in the structure would result in a decrease (increase) in energy use if a relative share of a more (or less) efficient transportation mode increases relative to other modes. Over the period, the shift between modes was the increase in the share of freight moved by heavy trucks relative to other modes. The overall effect on the structure was positive, given the increase in Canada-United States trade and the just-in-time delivery demanded by clients, thus contributing to a more intensive use of truck transportation. Hence, the structure effect contributed to a 255.6-PJ increase in energy use and an 18.1-Mt increase in greenhouse gas emissions.
- Energy efficiency – Improvements in the energy efficiency of freight transportation saved 86.8 PJ of energy and 6.2 Mt of greenhouse gas emissions. Improvements in freight trucks (light, medium and heavy trucks) were a large contributor, representing 79 percent of the savings.

Figure 1-18 shows how the market share of new light trucks increased in the 1990s, reflecting the increase in popularity of minivans and sport utility vehicles. Recently, however, this trend seems to have stabilized, with the share of light trucks remaining steady over the past few years. The higher share of heavier and more powerful passenger vehicles has

FIGURE 1-18 Market Shares of New Passenger Car and Light-Truck Sales, 1990 to 2009



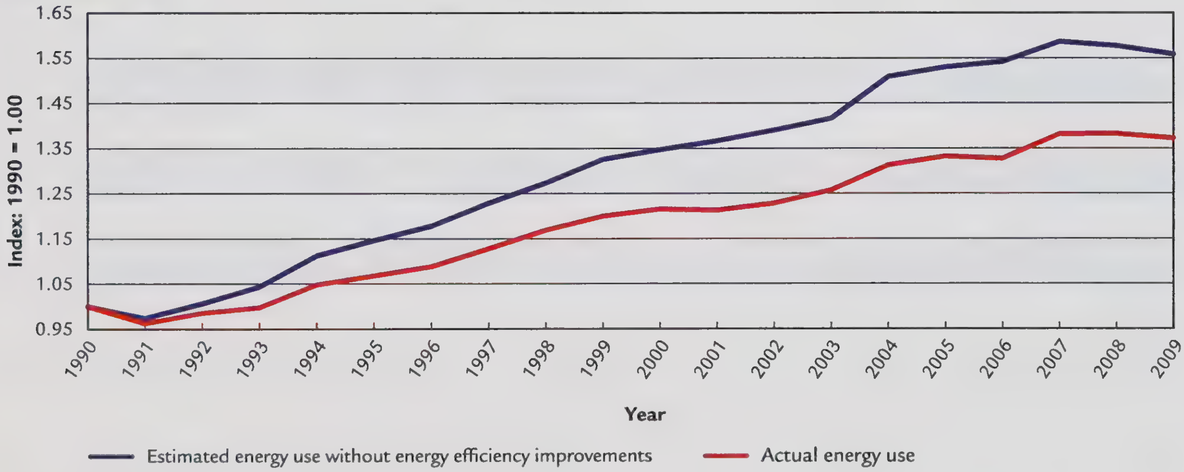
Source: oee.nrcan.gc.ca/corporate/statistics/neud/dpa/handbook_tran_ca.cfm?attr=0

had a significant effect on the increase in passenger energy use.

Energy Efficiency

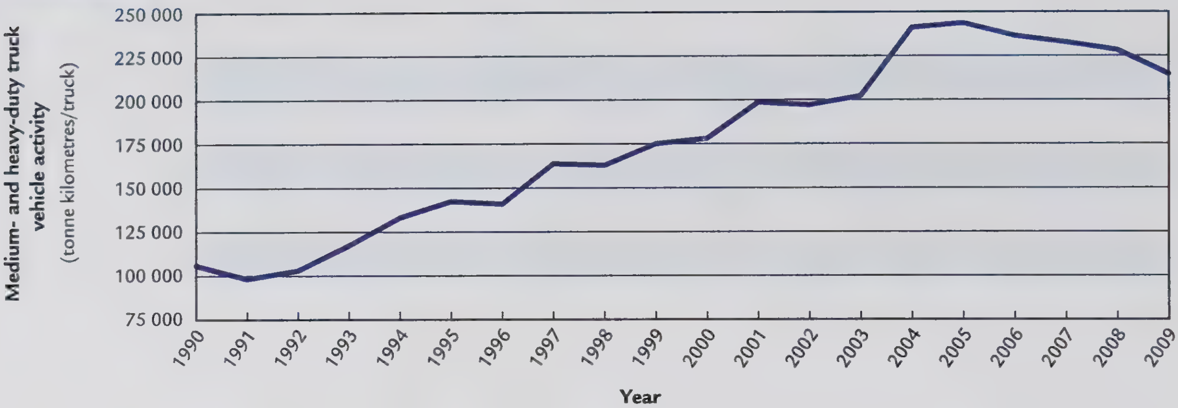
Between 1990 and 2009, energy efficiency in the transportation sector improved 19 percent, saving $8.7 billion or 350.1 PJ of energy. Without improvements in energy efficiency, increases attributable to activity and structure would have increased transportation energy use by 58 percent (see Figure 1-19). These savings were largely due to improvements in the efficiency of passenger and light-duty vehicles. Because this segment comprises a large share of vehicles on the road, savings generated by efficiency improvements had a significant impact on total energy use.

FIGURE 1-19 Transportation Energy Use, Actual and Without Energy Efficiency Improvements, 1990 to 2009



Source: oee.nrcan.gc.ca/corporate/statistics/neud/dpa/handbook_tran_ca.cfm?attr=0

FIGURE 1-20 Average Activity per Truck, 1990 to 2009



Source: oee.nrcan.gc.ca/corporate/statistics/neud/dpa/handbook_tran_ca.cfm?attr=0

Figures 1-20 and 1-21 illustrate an improvement in trucking energy intensity despite an increase in average activity from 1990 to 2009. Improved fleet practices, caused by an increase in the competitiveness (brought about by just-in-time inventory practices) in the transportation sector and by the introduction of electronic engines, have improved fuel efficiency in medium- and heavy-duty trucks.

In 2011–2012, NRCan carried out the following initiatives to increase energy efficiency in the transportation sector:

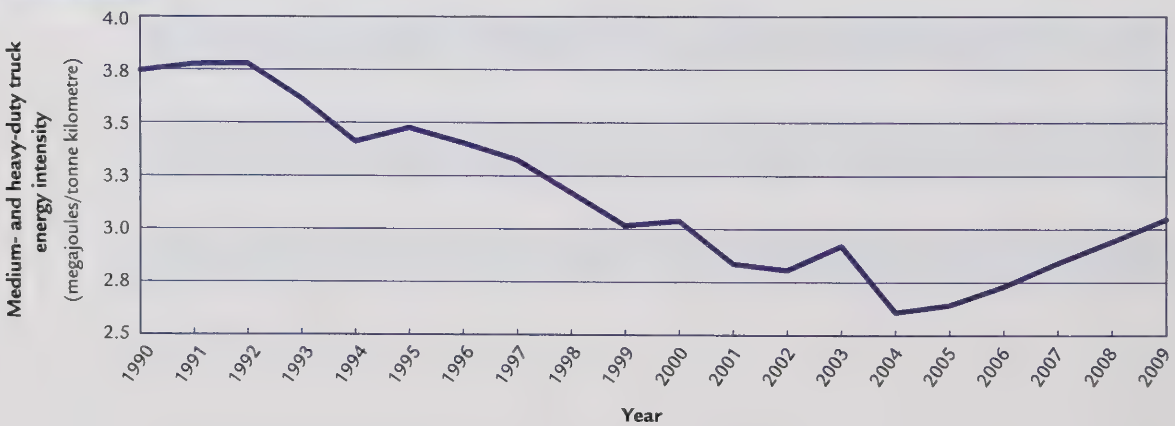
- ecoENERGY Efficiency for Vehicles
- Clean Transportation Energy

TRENDS IN ALTERNATIVE AND RENEWABLE FUELS

Alternative transportation fuels are fuels that are used for transportation other than petroleum-based gasoline and diesel. Some alternative transportation fuels, such as ethanol and biodiesel, are renewable; others, such as propane and natural gas, are non-renewable. Other possible alternative transportation fuels include next-generation biofuels, coal-to-liquids, electricity and hydrogen.

Renewable fuel is a broad term that covers a range of fuels made from renewable energy sources that are naturally replenished in a relatively short period. The

FIGURE 1-21 Trucking Energy Intensity, 1990 to 2009



Source: Natural Resources Canada, Transportation End-Use Model, Ottawa, 2011.

sources include biomass, hydropower, geothermal energy, wind energy and solar energy.

Biofuel is a well-known category of renewable fuel and can be produced from a variety of sources. Two commercially available biofuels are ethanol and biodiesel. Conventional ethanol is produced from sugars or starches, and biodiesel production typically uses vegetable oils and animal fats. In Canada, ethanol is typically produced from corn and wheat, while biodiesel is primarily produced from recycled greases, animal fats and canola oil.

Gasoline vehicles manufactured since the 1980s can use up to 10 percent ethanol in gasoline. An increasing number of original equipment manufacturers are endorsing the use of lower biodiesel blends, for example, up to 5 percent in diesel engines.

Under development are next-generation biofuels, such as cellulosic ethanol and renewable diesel. Cellulosic ethanol can be made from non-conventional sources, such as agricultural residues, forest residues and waste materials, whereas renewable diesel can be made from many of the same types of feedstocks as traditional biodiesel, such as recycled greases, animal fats and canola oil.

Renewable Fuels Production

Renewable fuels production in Canada has increased since the emergence of ethanol in Manitoba in the 1980s. Between 2005 and 2011, biofuel production capacity increased from 228 million litres (L) to 1.96 billion L: 1.73 billion L of ethanol and 225 million L of biodiesel. In 2011, approximately 1.66 billion L of ethanol were produced, and ethanol was part of about 5.9 percent of gasoline sales (an increase of 1.61 percent from 2010).

On December 15, 2010, Environment Canada's the *Renewable Fuels Regulations* (the Regulations) came into force. The Regulations require that gasoline produced or imported have an average annual renewable fuel content of at least 5 percent based on volume. The Regulations also require an average of 2 percent renewable content in diesel fuel and heating oil, subject to technical feasibility, effective July 2011. Technical feasibility was demonstrated through the National Renewable Diesel Demonstration Initiative that was led by NRCan.

In 2011–2012, NRCan carried out initiatives to increase the use and production of renewable and alternative fuels under the following programs:

- ecoENERGY for Biofuels
- ecoENERGY for Alternative Fuels
- Sustainable Development Technology Canada's NextGen Biofuels Fund™

Natural Gas Use in the Canadian Transportation Sector: Deployment Roadmap

Facilitated by NRCan, the *Natural Gas Use in the Canadian Transportation Sector: Deployment Roadmap* brought together stakeholders that represented government, industry, end-users, academia and environmental organizations to identify the optimal use of natural gas across the medium- and heavy-duty portions of the transportation sector.

The roadmap work culminated in a comprehensive report that includes 10 recommendations that stem from business modelling, consultation with end-users and an investigation of research and development needs. These recommendations cover four key areas: de-risking investment and early adoption, addressing information gaps, increasing capacity to sustain markets, and ensuring ongoing competitiveness. The final report is available online at oee.nrcan.gc.ca/alternative-fuels/natural-gas-deployment-roadmap.

CHAPTER 2
Equipment, Standards and Labelling

INTRODUCTION

Natural Resources Canada's (NRCan's) wide range of energy efficiency initiatives includes standards and labelling programs that are based on the requirements of Canada's *Energy Efficiency Regulations* (the Regulations).

The *Energy Efficiency Act* (the Act) of 1992 gives the Government of Canada the authority to make and enforce regulations that prescribe standards and labelling requirements for energy-using products that are imported to Canada or shipped across provincial borders for lease or sale. The Act was amended in 2009, making it possible to prescribe standards not only for more products that use energy but also for products, such as thermostats, that affect energy use.

The Regulations came into effect in February 1995, after extensive consultations with provincial governments, affected industries, utilities, environmental groups and others. Since then, the Regulations have been amended a number of times. Regulations have now been established for more than 40 products, including major household appliances, water heaters, heating and air-conditioning equipment, automatic icemakers, dehumidifiers, dry-type transformers, electric motors, commercial refrigeration and some lighting products. The Regulations apply to these products even if they are incorporated in a larger unit or machine that is not regulated.

NRCan regularly amends the Regulations to strengthen the minimum energy performance requirements for prescribed products when the market has achieved a higher level of efficiency. The Regulations are also amended to add new products, harmonize minimum energy performance requirements with those of other jurisdictions and update testing methodologies and labelling requirements.

In addition, regulations can be established for gathering market data on the energy performance of certain types of equipment. For example, the data gathered for gas fireplaces are used to support programs developed by the industry and the department and its partners for gas fireplace performance.

Before amending the Regulations, NRCan conducts studies to determine how a proposed change will affect the market. A key criterion for amending the Regulations is that the change must have a significant positive impact on consumers and the environment. Stakeholders are consulted on all proposed changes to the Act and the Regulations, as well as on their practical application in the marketplace.

The Act and the Regulations also support labelling initiatives. These initiatives are designed to help consumers and the commercial/industrial procurement community identify and purchase energy-efficient equipment that will save them money and reduce greenhouse gas emissions over the life of the product.

The Act and the Regulations require that a comparative EnerGuide label be displayed on major electrical household appliances and room air conditioners or, as in the case of the newly implemented requirement for light bulb labelling, on the product packaging. The EnerGuide label shows the energy performance of the product and

compares it with the most and least efficient models of the same class and size.

The EnerGuide label is also used voluntarily by manufacturers and suppliers of residential oil and gas furnaces, vented gas fireplaces, central air conditioners and air-to-air heat pumps; and, at the request of manufacturers during this reporting period, domestic water heaters. In these cases, the EnerGuide rating for a specific product is published on the back page of the manufacturer's brochure. These ratings include the annual fuel utilization efficiency rating for oil and gas furnaces, the fireplace efficiency rating for gas fireplaces, the seasonal energy efficiency ratio for central air conditioners, and the energy factor for domestic hot water.

The ENERGY STAR® Initiative in Canada works with and complements the Regulations and comparative EnerGuide label. The internationally recognized ENERGY STAR symbol is a simple way for consumers to identify products that are among the most energy-efficient on the market.

Products that are prescribed in the Regulations and are also part of ENERGY STAR must meet levels of energy efficiency significantly above the minimum performance levels set out in the Regulations to qualify for the ENERGY STAR symbol. As higher-performance products penetrate the market, their efficiency levels trigger the development of new minimum energy performance standards.

In September 2011, the Government of Canada announced funding for the ecoENERGY Efficiency program, which includes support for the continuation of energy efficiency standards and labelling efforts. Further savings of 35 petajoules (PJ) of energy and 4 megatonnes (Mt) of emissions are expected to result in 2020 from additional standards and complimentary voluntary efforts contained in the ecoENERGY Efficiency program.

STANDARDS

As a world leader in the use of energy efficiency standards, NRCan is committed to harmonizing standards and labelling requirements with those developed in other jurisdictions.

Harmonization reduces barriers to trade and sustainable development by improving the flow of energy-efficient products within Canada and around the world. This practice minimizes the regulatory burden on manufacturers and avoids confusion for consumers.

For example, the performance requirements in the Regulations are similar to those in the six Canadian provinces that currently regulate energy-using equipment manufactured and sold within their borders. This alignment is achieved because governments support and participate in the development of national, consensus-based performance standards by accredited standards-writing organizations, such as the Canadian Standards Association.

Such standards include testing procedures that determine a product's energy performance and are usually referenced federally and provincially. NRCan works closely with provinces throughout the regulatory process to ensure that the federal and provincial standards regimes are harmonized to the maximum extent possible.

Because the North American market is highly integrated, Canada's energy performance requirements for many products are strongly aligned with regulations in the United States. Canada is an active participant in international and regional forums, such as the U.S.-Canada Clean Energy Dialogue and the Clean Energy Ministerial. Both of these efforts contribute to regional co-operation on energy efficiency issues.

NRCan is also involved with the International Energy Agency Efficient Electrical End-use Equipment implementing agreement that facilitates co-operation among various Organisation for Economic Co-Operation and Development countries on specific projects. Canada is participating in a mapping and benchmarking study as well as one on standby power.

Canada has also been a participant in the Super-efficient Equipment and Appliance Deployment initiative, which is an initiative under the Clean Energy Ministerial and also a task group

under the International Partnership for Energy Efficiency Co-operation. The initiative has focused on furthering international collaboration on standards development, international best performers awards and tools to help procurement agencies identify and purchase high efficiency products.

The 2009 amendment to the *Energy Efficiency Act* broadened the scope of the Report to Parliament by the Minister of Natural Resources, as follows:

- Once every three years, "the Minister shall demonstrate the extent to which the energy efficiency standards prescribed under this Act are as stringent as comparable standards established by a province, the United Mexican States, the United States of America or a state of the United States of America."
- Within four years, the Minister shall "... demonstrate the extent to which energy efficiency standards have been prescribed under this Act for all energy-using products whose use has a significant impact on energy consumption in Canada."

In the last report, *Improving Energy Performance in Canada – Report to Parliament Under the* Energy Efficiency Act *For the Fiscal Year 2010–2011*, NRCan fulfilled the first of the above reporting requirements, indicating that our standards are as stringent as about 90 percent of those compared.

An internal study was undertaken to estimate the country-wide energy consumption resulting from the use of energy-using products prescribed under the Regulations. This fulfills the second reporting requirement and is summarized here.

In the residential sector, efficiency standards have been prescribed for more than 30 energy-using product categories, which represent almost three quarters (74 percent) of total residential energy use in Canada. This can be broken down by energy-using product category, as illustrated in Table 2-1. For example, 97 percent is used by a regulated product as is 65 percent of energy used for space heating. Some of the energy use not covered by the Regulations may be covered in future years when new regulatory proposals are introduced. For example, a regulatory proposal is being developed for line voltage thermostats, a component of electric baseboard heaters, which use 14 percent of residential energy use and are currently not regulated.

The Regulations also address products specifically marketed to the commercial sector. Energy efficiency standards have been prescribed for more than 20 commercial product categories, which represent more than 30 percent of total commercial energy use in Canada. This can be broken down by energy-using product category, as illustrated in Table 2-1. For example, 85 percent of the energy used for lighting is used by regulated products as is 67 percent of the energy used by auxiliary motors.

Key commercial energy-using products that are not currently regulated at the federal level include commercial water heaters (electric, gas and oil-based), space heating and cooling equipment (gas and oil-fired boilers, oil-fired furnaces, infrared heaters, duct furnaces, electric baseboards, rooftop units, air handlers, make-up air units), and auxiliary equipment. Many of these products are currently the subject of regulatory proposals and are likely to be included in future amendments to the Regulations.

Finally, efficiency standards have been prescribed for several products commonly used in the industrial sector, most notably dry-type transformers and motors, which comprise 38 percent of industrial electricity use and 8 percent of total industrial energy use in Canada.

In keeping with its mandate to strengthen and expand Canada's commitment to energy efficiency, the Office of Energy Efficiency (OEE) at NRCan continues to endeavour to update the Regulations. The upcoming amendment to the Regulations that is scheduled for pre-publication in the coming year, if adopted, would tighten efficiency standards for eight product categories – gas-fired water heaters, oil-fired water heaters, commercial self-contained refrigerating devices, packaged terminal air conditioners and heat pumps, chillers, general service fluorescent lamps, general service incandescent reflector lamps, and room air conditioners.

TABLE 2-1 Energy Use from Regulated Products, 2009

Product category	Total energy use (PJ)[1]	Estimated energy use from regulated products (PJ)	Energy use from regulated products (%)
Residential sector			
Space heating	893.2	580.4	65
Water heating	245.8	238.9	97
Appliances	205.2	168.2	82
Lighting	60.6	44.2	73
Space cooling	17.4	17.0	97
Total residential	**1422.3**	**1048.7**	**74**
Commercial sector[2]			
Space heating	594.0	144.6	24
Water heating	96.0	0.0	0
Auxiliary equipment	225.0	12.8	6
Auxiliary motors	100.0	67.5	67
Lighting	126.0	107.6	85
Space cooling	38.0	20.2	54
Street lighting	8.0	1.4	18
Total commercial	**1186.0**	**354.2**	**30**
Industrial sector[3]			
Total industrial	**2991.9**	**250.7**	**8**

Notes
1 Figures are based on preliminary 2009 data from the National Energy Use Database.
2 Excludes spill-over of residential products in the commercial sector.
3 Excludes spill-over of residential and commercial products in the industrial sector.

COMPLIANCE AND ENFORCEMENT

The Regulations outline some responsibilities of dealers who import to Canada or ship from one Canadian province to another for the purpose of sale or lease, any prescribed energy-using product.

NRCan emphasizes self-monitoring, reporting, voluntary compliance and collaboration. However, the Act prescribes specific enforcement measures when dealers violate the law.

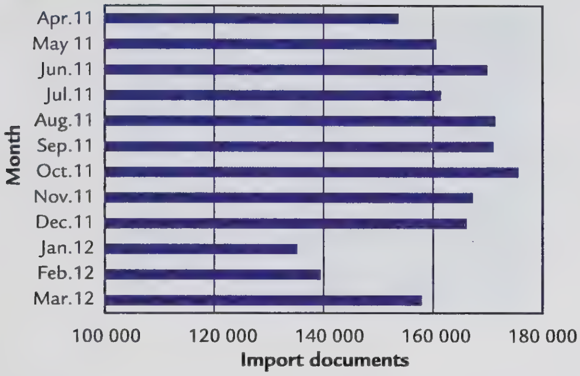
To monitor compliance with the Regulations, the department captures information from energy efficiency reports and import documents. Section 5 of the Act requires dealers to provide energy efficiency reports when they market a new product model. The required information includes the energy performance of each model, the name of the certification body that verified the energy performance of the product and the size category, as described in Schedule IV of the Regulations.

The Regulations require that when importing a regulated product into Canada, dealers provide specific product information on customs documents for all shipments (i.e. type of product, brand name, model number, address of dealer and purpose of import). A customs document contains less information than an energy efficiency report, but there is enough to allow the department to verify that there is a matching energy efficiency report. The department can then confirm that all products entering Canada meet the required energy performance levels and can take action when necessary.

NRCan processed more than 1.93 million records (records from April 1, 2011 to March 31, 2012) relating to the importation of regulated energy-using products to Canada in 2011–2012.

Figure 2-1 illustrates the volume of import documents received, in paper form and electronically, per month during the 2011–2012 fiscal year.

FIGURE 2-1 Volume of Monthly Import Documents



Source: OEE Equipment Database.

More than 3.62 million new or revised model numbers were submitted to NRCan for entry into the department's equipment database (records from April 1, 2011 to March 31, 2012) from dealers' energy efficiency reports.

REGULATORY IMPACT TO DATE FROM THE REGULATORY IMPACT ANALYSIS STATEMENT

In preparing amendments to the Regulations, NRCan analyses the impact of the proposed amendment on society, the economy and the environment. This information is made available through the Regulatory Impact Analysis Statement, which is annexed to the Regulations and published in the *Canada Gazette, Part II.*

It is estimated that Canada's energy performance standards from the 12 amendments have resulted in a reduction of 26.03 Mt in aggregate annual greenhouse gas emissions in 2010 (see Table 2-2).

During 2011–2012, the department conducted the analysis and consultation necessary to implement Amendment 11, the second amendment of the Clean Air Regulatory Agenda. Amendment 11 was published in October 2011 and came into effect in April 2012. Regulatory amendment 12, which delayed the implementation of standards for light

TABLE 2-2 Estimated Impact of the *Energy Efficiency Regulations*, 2010 and 2020 (Aggregate Annual Savings)

Product (amendment number in brackets)	Energy savings (PJ)		Greenhouse gas reductions (Mt)	
	2010	2020	2010	2020
Residential appliances (1)	117.20	133.84	13.26	15.60
Lamps - fluorescent/incandescent (2)	11.60	13.40	7.55	9.80
Motors (3)	16.30	17.70	2.03	2.14
Commercial HVAC (4)	6.40	7.50	0.43	0.57
Refrigerators (5)	4.92	10.96	0.25	0.67
Ballast/room A/C, PAR lamps (6)	3.96	9.44	0.60	1.20
Clothes washers, domestic water heaters, exit signs, chillers (8)	16.12	42.59	1.28	3.60
A/C, commercial refrigeration (9)	1.64	5.51	0.16	0.55
General service lighting, commercial and industrial gas unit heaters, traffic and pedestrian signals, ceiling fan lighting, torchiere lamps, commercial clothes washers, residential wine chillers, commercial ice-makers, residential dishwashers, residential dehumidifiers, residential gas furnaces (10)	6.09	88.10	0.40	9.67
Residential boilers, dry-type transformers, commercial three-phase induction motors, external power supplies, large air conditioners and heat pumps, room air conditioners, standby power, commercial reach-in refrigerators, digital television adaptors, residential general service incandescent reflector lamps, industrial three-phase induction motors, commercial general service incandescent reflector lamps (11)	0.55	7.50	0.07	0.96
Change to implementation dates for general service lighting (12)	0.00	0.07	0.00	-0.01
Total	**185.15**	**336.47**	**26.03**	**44.75**

bulbs for two years, was also published November 2011. Analysis and legal drafting of the provisions of Amendment 13 were mostly completed in 2011–2012. The department also responded to the Government's regulatory reform commitments by aligning its regulatory planning for energy efficiency standards with the recently announced "One-for-One" rule and small business lens.

The final 2020 projected energy efficiency impacts of the published and soon-to-be pre-published amendments (Amendments 10 to 13) are savings of 105.61 PJ of energy and 11.22 Mt of greenhouse gas emissions.

LABELLING AND PROMOTION

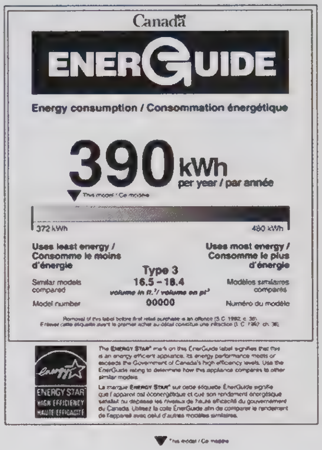
EnerGuide Label

Since 1978, the EnerGuide label has given Canadians the opportunity to compare the energy consumption of appliances (see Figure 2-2). In 1995, with the introduction of the Regulations, placing an EnerGuide label on major electrical household appliances and room air conditioners became mandatory. The label on a product shows how much energy a product uses within the range of products within its category, allowing the customer to consider the most energy-efficient choice.

EnerGuide directories that list energy ratings for major appliances and room air conditioners are published annually. They are distributed to consumers, retailers and appliance salespeople. In fulfilling requests for information, electric utilities and provincial governments also distribute the directories. Online directories for all appliances and heating and cooling equipment are published on the Web site of the OEE and updated monthly.

A voluntary EnerGuide rating program was established in 1997 and included gas furnaces, central air conditioners, heat pumps and oil furnaces. In 2003, gas fireplaces were added to the EnerGuide rating program, and manufacturers were asked to include EnerGuide ratings for fireplace efficiency in their brochures. These changes coincided with the mandatory requirement in the Regulations to test, verify and report on fireplace efficiency. In

FIGURE 2-2 EnerGuide Label



2011, manufacturers of domestic water heaters asked NRCan to allow them to voluntarily use the EnerGuide label to indicate the energy use of their products as well. The expansion of the voluntary rating program to this product category will help Canadian consumers make better purchase decisions in these highly competitive product categories.

Major distributors of these products for sale in Canada report the verified energy performance rating of their products, as tested against the standards in the Regulations. In addition, participants in the voluntary EnerGuide rating program must provide shipment data and aggregate energy efficiency information to track the progress of the program and identify marketplace improvements that can result from labelling.

Given that the equipment products listed above are typically purchased from a brochure or catalogue, a consumer would likely not read the EnerGuide label before making a decision to buy. Accordingly, manufacturers are encouraged to include an EnerGuide rating in product brochures and catalogues, so consumers can compare the efficiency of products when they are in the buying process. To date, manufacturers of 85 percent of eligible products on the market voluntarily participate in the EnerGuide rating program and publish the ratings in their brochures. Regularly conducted polls indicate that more than 50 percent of Canadians surveyed are aware of the EnerGuide label.

ENERGY STAR Label

In 2001, responding to public interest in a labelling system that identifies the best performers, Canada officially introduced ENERGY STAR, the international symbol for energy efficiency (see Figure 2-3). NRCan administers the ENERGY STAR program in Canada under a letter of agreement with the U.S. Environmental Protection Agency and the U.S. Department of Energy. Canada joins other international ENERGY STAR program participants: Australia, New Zealand, Japan, Taiwan and the European Union, which adopted ENERGY STAR for office equipment. The OEE is the custodian of the program for Canada.

FIGURE 2-3 ENERGY STAR Symbol

ENERGY STAR establishes high-efficiency criteria and levels for selected products for the residential and commercial sectors. Product categories are selected on the basis of their technical potential for high efficiency.

This is a voluntary program. However, organizations must demonstrate that products meet the eligibility criteria and performance levels. In Canada, organizations apply to become participants in the ENERGY STAR initiative, thereby pledging to promote the brand and the concept of energy efficiency in both their operations and consumer literature. NRCan, in turn, offers its support in the way of promotional and educational tools for retailers and manufacturers. This year, several retailer training products were developed to ensure sales personnel knew how to market the most efficient products to consumers.

DID YOU KNOW?

By replacing your home's five most frequently used incandescent light bulbs with ENERGY STAR qualified products, you can save $70 each year in electricity costs. The *lumen* value (light output) of the bulb is more important than *wattage* (energy use). Remember, for newer lighting technologies such as CFLs (compact fluorescent lamps) and LEDs (light-emitting diodes), the light bulbs can produce the same lumen output by using fewer watts than traditional incandescent bulbs.

The criteria for efficiency specifications for appliances and heating and cooling products are based on the same test standards as those applied under the Regulations. Canada promotes specific product categories for which levels and criteria can be harmonized with those of the United States, including the following:

- major electrical appliances
- heating, cooling and ventilation equipment
- consumer electronics
- office equipment
- windows, doors and skylights (Canadian levels)
- selected lighting products – compact fluorescent lamps, fixtures, decorative light systems and solid-state lighting
- selected commercial equipment, including commercial kitchen products

Canada has integrated ENERGY STAR with the EnerGuide label for qualified major appliances and room air conditioners to help consumers identify the best-performing products. While the EnerGuide label shows how much energy a product uses under normal conditions in one year, the ENERGY STAR symbol on the label identifies products that meet higher efficiency standards. ENERGY STAR has become the criterion to meet for incentive and rebate programs and is used by many electrical and gas utilities across Canada. For example, in 2011-2012,

Hydro-Québec offered rebates for ENERGY STAR compact fluorescent lamps, Hydro One (Ontario), BC Hydro and FortisBC™ offered rebates on a variety of ENERGY STAR qualified appliances throughout the year, and the utilities of Newfoundland and Labrador offered rebates on ENERGY STAR qualified windows. The Ontario Power Authority had retailer incentive programs and coupon rebates for consumers to purchase ENERGY STAR qualified products, and Manitoba Hydro ran incentive programs for ENERGY STAR qualified commercial kitchen equipment.

ENERGY STAR was also a qualifying criterion for sales tax exemptions in Saskatchewan and Ontario for the purchase of home heating equipment. Organizations across Canada, especially utilities, have used ENERGY STAR as a campaign driver to promote replacement with, or purchase of, higher efficiency products.

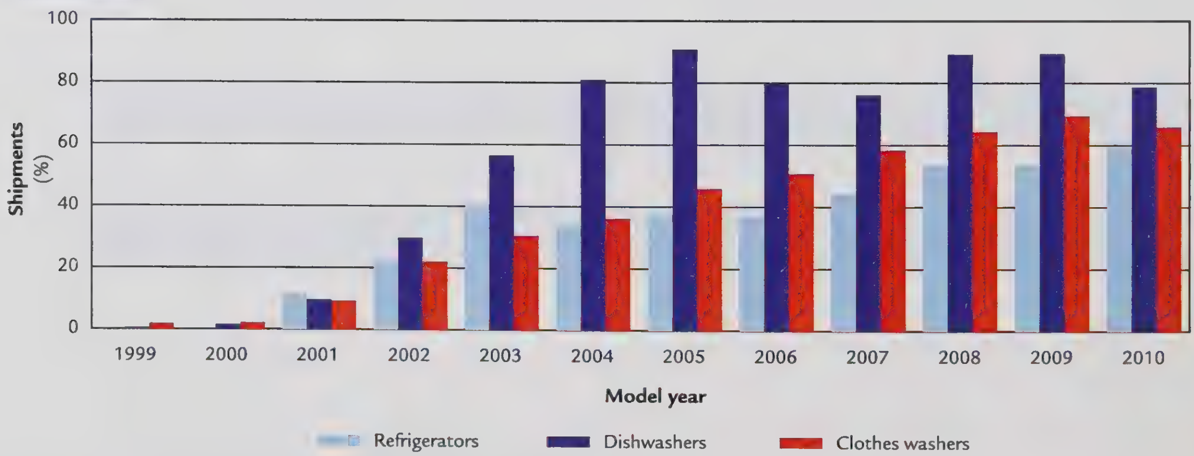
Continuous promotion of ENERGY STAR qualified appliances has paid off. Industry statistics for 2010 show an increase in market penetration from almost nil in 1999 to 59 percent for refrigerators, 66 percent for clothes washers and 79 percent for dishwashers (see Figure 2-4). The increase in market penetration indicates growing acceptance of ENERGY STAR as the brand for high energy efficiency and manufacturers' willingness to raise the efficiency of their products to qualifying levels.

ENERGY STAR specifications and levels are routinely updated as product saturation is reached, to encourage industry to strive for more efficient products and thus maintain the relevance and credibility of the brand.

ENERGY STAR is also well known in the commercial sector, with criteria for products ranging from office and kitchen equipment to vending machines. With more products added to the ENERGY STAR lineup this year, NRCan offered a commercial kitchen purchasing guide for commercial and institutional kitchen managers, owners, and those purchasing for large restaurant chains in Canada. NRCan supports demonstration projects to validate the savings and other benefits of some of these products and to address barriers to their widespread acceptance.

Canada continues to promote ENERGY STAR guidelines in its contacts with the procurement community and keeps its interactive cost calculators and purchasing tool kits up to date. This ensures that procurement professionals have access to useful data and tools that help them compare energy cost savings and reductions in greenhouse gas emissions associated with the purchase of ENERGY STAR qualified products. This information is needed to make a solid business case for investing in more efficient equipment, in spite of the "first price tag" – which is often a barrier in bulk purchases of energy-using equipment.

FIGURE 2-4 ENERGY STAR Qualified Appliances as a Percentage of Total Shipments in Canada, 1999 to 2010

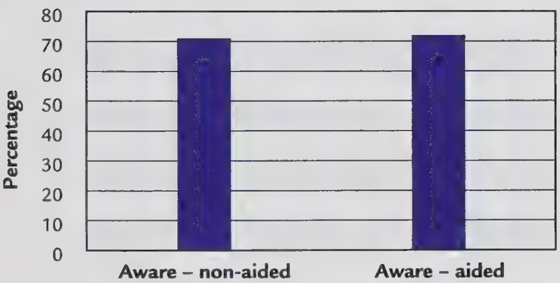


Source: *Energy Consumption of Major Household Appliances Shipped in Canada, Trends for 1990–2010.*

Workshops were held across Canada to make governments and institutions aware of the ENERGY STAR criteria and procurement tools. Dalhousie University was the first university in Canada to become an ENERGY STAR participant.

Canada is also working with housing agencies to help them identify energy savings in their properties and to specify ENERGY STAR qualified products for replacement equipment. For example, in the ENERGY STAR for New Homes initiative, a builder or homeowner must also consider purchasing ENERGY STAR qualified appliances, lighting products and other optional equipment to reach the highest efficiency standards to earn the ENERGY STAR mark, in addition to incorporating major components in the construction of the home that meet or exceed ENERGY STAR specifications. Canada continues to expand the range of product types included in its ENERGY STAR agreement with four product categories added in 2011 and stringency increased for more than17 others.

FIGURE 2-5 ENERGY STAR Awareness Levels in Canada, 2010



Source: Tracking Study: Awareness of ENERGY STAR / EnerGuide Symbols 2010, Ipsos Reid.

ENERGY STAR Most Efficient Designation

Under Phase 1 of the Clean Energy Dialogue between Canada and the United States, NRCan and the United States collaborated to enhance the ENERGY STAR program. In 2011, the Environmental Protection Agency and the Department of Energy launched an initiative called "Most Efficient" to identify and promote the most efficient products among those that qualify for the ENERGY STAR label in selected product categories. Canada reciprocated by conducting market analysis to determine the potential for the program in Canada. Under Phase 2 of the Clean Energy Dialogue, the department is initiating similar improvements to replicate elements of the Most Efficient program in Canada.

Availability of the Most Efficient program will advance highly efficient products in the Canadian marketplace. Most Efficient product categories and performance criteria ensure that products that earn this recognition demonstrate efficiency performance that is truly exceptional or leading edge – consistent with the interests of environmentally motivated consumers and early adopters. These products are "the best of the best" in terms of energy performance. By choosing these energy-efficient products, consumers can decrease their energy consumption, save money on their energy bills and reduce greenhouse gas emissions.

FIGURE 2-6 ENERGY STAR Most Efficient Logo

Most Efficient
2011
Les plus éconergétiques
ENERGY STAR
energystar.nrcan.gc.ca

CHAPTER 3

Energy Efficiency and Alternative Transportation Fuels

Natural Resources Canada's (NRCan's) Office of Energy Efficiency (OEE) aims to strengthen and expand Canada's commitment to energy efficiency across all sectors and increase the production and use of alternative transportation fuels in Canada. The OEE manages several initiatives under the suite of ecoENERGY programs, including

- ecoENERGY Efficiency, which features the following program components:
  - ecoENERGY Efficiency for Buildings
  - ecoENERGY Efficiency for Housing
  - ecoENERGY Efficiency for Equipment Standards and Labelling
  - ecoENERGY Efficiency for Industry
  - ecoENERGY Efficiency for Vehicles
- ecoENERGY Retrofit – Homes
- ecoENERGY for Alternative Fuels
- ecoENERGY for Biofuels
- Federal Buildings Initiative

This chapter describes the objective of each of the aforementioned programs and outlines key achievements.

ecoENERGY EFFICIENCY

The ecoENERGY Efficiency program is investing $195 million over five years to maintain the Government of Canada's momentum to improve energy efficiency in Canada – at home, at work and on the road. These efforts will make the housing, building, and equipment stock more energy-efficient, energy performance more visible and industry and vehicle operations more efficient.

Improving energy efficiency will contribute to a cleaner environment and reduce greenhouse gas emissions while saving Canadians money and making the most of our natural resources. The ecoENERGY Efficiency program is expected to result in energy savings of 36 to 44 petajoules by March 31, 2016.

Details on each of the featured components of the ecoENERGY Efficiency program can be found below.

ecoENERGY EFFICIENCY FOR BUILDINGS

Objective

ecoENERGY Efficiency for Buildings, a component of the ecoENERGY Efficiency program, supports the development and implementation of energy codes, benchmarking tools, training and information materials to improve the energy efficiency of commercial and institutional buildings in Canada.

Description

The ecoENERGY Efficiency for Buildings program component will improve the efficiency of new and existing buildings in Canada's commercial and institutional sector. Activities include

- providing technical, policy and financial support to the National Research Council of Canada to upgrade the 2011 National Energy Code of Canada for Buildings, resulting in publication of the 2015 version of the energy code. The updated code will ensure improved minimum performance for new buildings, which, in 2020, will make up 25 percent of the building stock. NRCan will work with the National Research Council, the federal organization responsible for code development, and will collaborate with provincial, territorial and

municipal government authorities responsible for code adoption. In addition, information, tools, training and best practices will be shared with responsible jurisdictions to encourage compliance to the code and energy efficiency in new buildings.

- developing and releasing new guidelines for the renovation of existing buildings that are not addressed by the improvements in the 2015 edition of the National Energy Code of Canada for Buildings. Existing buildings will account for 75 percent of the stock in 2020.
- adapting and introducing the United States Environmental Protection Agency ENERGY STAR program's Portfolio Manager benchmarking tool in Canada. Based on the United States experience, it is expected that this tool will be used in up to 6 percent of commercial and institution floor space in Canada by 2015–2016 (3000 to 4000 buildings). The benchmarking tool will provide building owners with a consistent way of comparing the energy performance of buildings, prompting them to make building improvements.
- developing and providing information, tools and training to encourage energy efficiency action through workshops such as NRCan's Dollars to $ense and others; NRCan's Web site; face-to-face and Web-enabled events; and collaborative arrangements to foster capacity building, transfer knowledge and support the implementation of energy management projects and practices.

DID YOU KNOW?

The National Energy Code of Canada for Buildings 2011 is now available for provinces and territories to adopt. The 2011 code is 25 percent more stringent than the previous code, which translates into $1.7 million in savings through the lifetime of a typical 10-storey building. The 2011 code calls for the highest energy performance in North America, and 10 provinces and territories are considering adopting or adapting it.

Key 2011–2012 Achievements

- The 2011 National Energy Code of Canada for Buildings was published.
- CanQuest – a building energy simulation software tool for energy code compliance – was launched.
- A new Dollars to $ense recommissioning workshop was launched.
- A Co-operative Research and Development Agreement with the U.S. Environmental Protection Agency was signed.
- More than 1250 participants were trained.
- Four partnerships, collaborative arrangements and/or agreements were signed.

For more information:
oee.nrcan.gc.ca/buildings

ecoENERGY EFFICIENCY FOR HOUSING

Objective

ecoENERGY Efficiency for Housing, a component of the ecoENERGY Efficiency program, encourages the construction and retrofit of low-rise residential housing, making the housing stock more energy-efficient.

Description

ecoENERGY Efficiency for Housing, will increase the energy efficiency of Canadian housing, as measured by increased energy performance of houses that participate in its initiatives. Activities include

- the EnerGuide Rating System, which is a standard measure of the energy performance of new and existing homes. The rating allows individuals to compare the energy performance of one house against another. For new homes, this rating and labelling system plays an important role in the construction of energy-efficient new homes. For existing homes, the EnerGuide Rating System is used to evaluate home energy efficiency and to provide guidance for homeowners who want to make energy improvements to their house. It is

also used as a part of the application process for incentives, through programs such as ecoENERGY Retrofit – Homes and its complementary regional programs. Getting an EnerGuide evaluation is promoted as the first step in smart home renovation.

- the ENERGY STAR for New Homes initiative, which promotes construction of new homes that are more energy-efficient than those built to minimum building code requirements. The increased efficiency of these homes translates into reduced energy costs for homeowners. ENERGY STAR qualified homes are now available in many regions in Canada.

- the R-2000[7] Standard, which is a voluntary standard administered by NRCan and is delivered through a network of service organizations and professionals across Canada.

  All R-2000 homes are constructed by licensed and trained builders, evaluated, inspected and tested by independent third-party inspectors, and are certified by the Government of Canada. R-2000 certified houses are significantly more energy-efficient than those built to minimum building code requirements and have additional elements such as clean air features and high levels of insulation. This translates into energy savings, increased comfort and a healthier environment for the homeowner.

Figure 3-1 shows the number of R-2000 certified houses and ENERGY STAR labelled houses from 1990 to 2011.

Key 2011–2012 Achievements

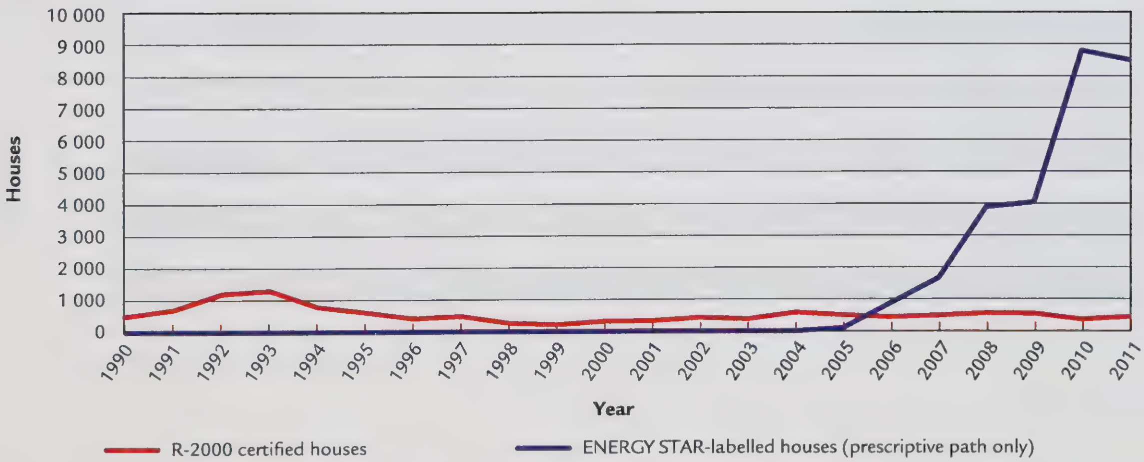
- More than 800 builders, energy professionals and trades people were trained.
- More than 230 000 energy labels were issued.
- Twenty-two agreements were established with delivery networks, non-governmental programs, provinces/territories and utilities.
- Seven jurisdictions are using the EnerGuide Rating System in the development or implementation of codes and regulations.

For more information:

oee.nrcan.gc.ca/housing

[7] R-2000 is an official mark of Natural Resources Canada.

FIGURE 3-1 Number of R-2000 House Certifications and ENERGY STAR Prescriptive-labelled Houses, 1990 to 2011



Source: NRCan national housing database and internal data.

ecoENERGY EFFICIENCY FOR EQUIPMENT STANDARDS AND LABELLING

Objective

The objective of ecoENERGY Efficiency for Equipment Standards and Labelling, a component of the ecoENERGY Efficiency program, is to eliminate the worst energy performers and accelerate the introduction of more energy-efficient products in Canada's equipment stock. To do this, the component will introduce new and more stringent regulated minimum energy efficiency performance standards and deploy enabling initiatives and strategies to ensure that there are continued improvements and a growing market share of energy-efficient products.

Description

The ecoENERGY Efficiency for Equipment Standards and Labelling program component builds on the success of previous programs by supporting three integrated elements to improve the efficiency of energy-using products sold in Canada and thus reduce greenhouse gas emissions. Activities include

- continuing to implement regulated minimum energy efficiency standards through amendments to the *Energy Efficiency Regulations*.

  These standards will eliminate the worst performing products from the Canadian marketplace. Standards may be proposed for the following 16 products:

  - battery charging systems
  - walk-in refrigerator/freezers
  - residential refrigerators, refrigerator-freezers
  - small electric motors
  - room air conditioners
  - residential dishwashers
  - ceiling fan lighting
  - residential clothes dryers
  - pool heaters
  - HID lamps
  - microwave ovens
  - televisions
  - fluorescent lamp ballasts
  - low-voltage dry-type transformers
  - residential clothes washers
  - commercial household-style clothes washers

  Additional standards will be considered consistent with developments in other jurisdictions.

  This program component will include ongoing support for core activities such as standards development through the national standards system for energy efficiency and delivering an effective service-oriented compliance and enforcement regime.

- enhancing labelling and promotion programs that have historically helped introduce new and more stringent standards and that are closely aligned with United States developments.

  Enhancements include a pilot program that focuses on the best performers of ENERGY STAR qualified products that will be launched as "Most Efficient." Refrigerator-freezers, washing machines, central air conditioners and televisions will be included in the Most Efficient pilot.

  The ecoENERGY Efficiency for Equipment Standards and Labelling program component will also continue to update and develop ENERGY STAR information material, tools and promotional and training activities. These efforts help procurement officials incorporate ENERGY STAR into purchasing decisions and demonstrate the energy and cost savings associated with choosing ENERGY STAR qualified products.

- accelerating the introduction of new high-efficiency products to the market by providing support for product showcases, deployment and monitoring.

- Integrated systems, high performance combustion systems and advanced lighting are examples of applications that may be showcased.

Key 2011–2012 Achievements

- The Most Efficient ENERGY STAR designation was introduced.
- Four market barrier assessments were completed for regulated products (refrigerators, clothes dryers, oil furnaces and mobile furnaces).
- Four technology assessments were undertaken.
- Four test standards were developed and published as National Standards of Canada.
- Amendments 11 and 12 to the Energy Efficiency Regulations were published.

For more information:
oee.nrcan.gc.ca/equipment

ecoENERGY EFFICIENCY FOR INDUSTRY

Objective

ecoENERGY Efficiency for Industry, a component of the ecoENERGY Efficiency program, aids the adoption of an energy management systems standard and accelerates energy-saving investments and the exchange of best-practices information within Canada's industrial sector.

Description

The ecoENERGY Efficiency for Industry program component provides information and training to improve the energy efficiency of Canadian industrial companies. Activities include

- supporting the Canadian Industry Program for Energy Conservation, which offers networking opportunities for industry to share information, identify common needs and best practices and improve energy efficiency in more than 25 industrial sectors.
- supporting early implementation of the new International Organization for Standardization ISO 50001 Energy Management Systems standard. The recent publication of the Canadian version of this new standard by the Canadian Standards Association will help Canadian industry establish the systems and processes necessary to take a structured approach to improving energy efficiency, use, consumption and intensity. Use of the standard will help Canadian industries remain competitive for the long run.
- providing Dollars to $ense energy management training workshops to help industrial companies reduce energy use by improving energy management practices.
- providing newsletters, reports, guides, manuals and publications to increase awareness of industrial energy efficiency.

Key 2011–2012 Achievements

- Pilots for implementing the ISO 50001 Energy Management Systems standard under the Clean Energy Dialogue (Global Superior Energy Performance Initiative) were completed.
- A new Dollars to $ense Energy Management Information Systems workshop was launched to support improved energy management practices.
- More than 1950 participants were trained through energy conferences, webinars and Dollars to $ense workshops.
- NRCan entered into seven partnerships, collaborative arrangements and/or agreements.
- NRCan supported adopting the new ISO 50001 as the national energy management standard for voluntary use by Canadian organizations.

DID YOU KNOW?

Two Canadian companies are now certified under the new ISO 50001 energy management systems standard, which was adopted by Canada in June 2011. This voluntary standard provides organizations with a structured framework to manage energy to increase efficiency, reduce costs and improve performance. It allows companies to demonstrate corporate environmental responsibility in the global marketplace.

For more information:
oee.nrcan.gc.ca/industry

ecoENERGY EFFICIENCY FOR VEHICLES

Objective

ecoENERGY Efficiency for Vehicles, a component of the ecoENERGY Efficiency program, aims to raise awareness regarding the impact of vehicle choice and driving style on fuel efficiency and the environment through information products, decision-making tools and training.

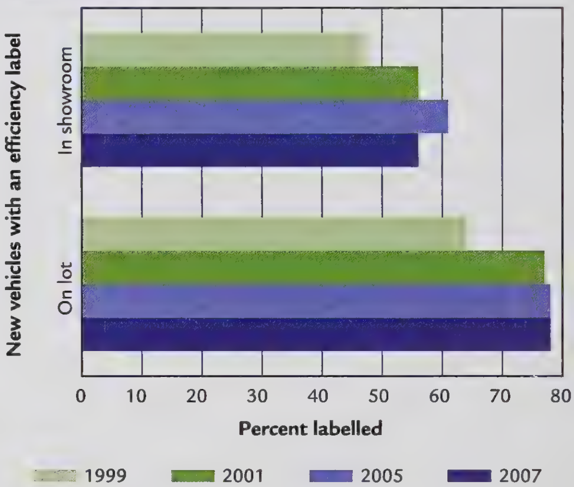
Description

The ecoENERGY Efficiency for Vehicles program component offers fuel-efficient driver training, provides energy information to vehicle consumers and encourages fleet managers to make their operations as energy-efficient as possible. Activities include

- helping Canadians understand the links between their driving behaviour and fuel consumption through fuel-efficient driver training and other tools is a key pillar of ecoENERGY Efficiency for Vehicles:
  - Auto$mart targets novice light-duty vehicle drivers.
  - SmartDriver targets drivers in the commercial and institutional fleet sector.
  - Commercial and institutional fleets will also have access to additional practical advice, tools and strategies offered through FleetSmart.
- ecoENERGY Efficiency for Vehicles also focuses on providing consumers with the information they need to make decisions about purchasing energy-efficient vehicle and equipment. This includes
  - continuing to produce the *Fuel Consumption Guide* and provide on-line consumer fuel efficiency information
  - introducing updated energy efficiency labels for light-duty on-road vehicles
  - developing a new consumer awareness initiative that recognizes fuel-efficient tires for light-duty vehicles
- ecoENERGY Efficiency for Vehicles will also introduce a Canadian version of the SMARTWAY Transport Partnership, a successful program launched by the U.S. Environmental Protection Agency in 2004:
  - SmartWay connects freight shippers with an interest in greening their operations to a list of endorsed energy-efficient freight carriers.
  - Participants are benchmarked against each other by using data they submit that describes their energy use and emissions.

Figure 3-2 shows the use of new vehicle fuel efficiency labelling and Figure 3-3 shows the company average fuel consumption versus Canadian voluntary standards.

FIGURE 3-2 New Vehicle Fuel Efficiency Labelling



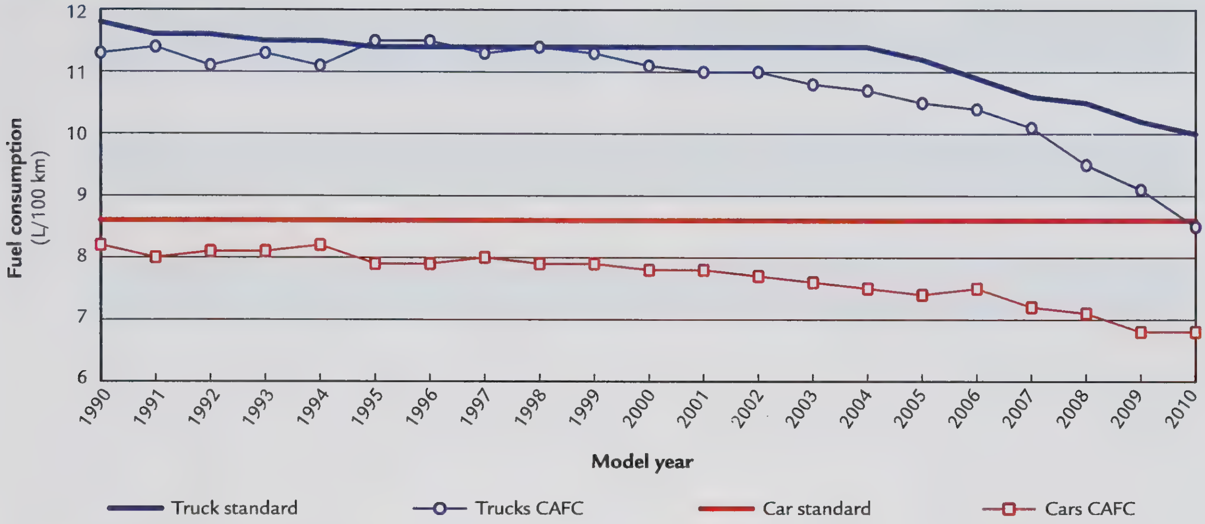
Source: Corporate Research Associates, *2007 EnerGuide Label for Vehicles and Fuel Consumption Guide Audit Survey: Final Overall Report, May 2007.*

DID YOU KNOW?

If every driver of a light-duty vehicle avoided idling for 3 minutes a day, collectively over one year, we would save 630 million litres (L) of fuel, more than 1.4 million tonnes of greenhouse gas emissions and $819 million annually in fuel costs.[8]

[8] Assuming an average fuel price of $1.30/L.

FIGURE 3-3 Company Average Fuel Consumption (CAFC) Versus Canadian Voluntary Standards, 1990 to 2010*



*2009 and 2010 data are estimates.
Source: www.tc.gc.ca/eng/programs/environment-fcp-cafctargets-385.htm

Key 2011–2012 Achievements

- In 2010–2011, the development of a SmartWay Transport Partnership network started. The focus will be on on-road freight movement, which will help both shippers and carriers improve their fuel efficiency and reduce their carbon footprint.
- New fuel-efficient driving instructional material for both light-duty vehicle drivers and medium- and heavy-duty vehicle professional drivers was developed.
- More than 210 000 new drivers and 4300 fleet drivers were trained in efficient driving practices.

For more information:
vehicles.nrcan.gc.ca

ecoENERGY RETROFIT – HOMES

Objective

To help homeowners and owners of existing low-rise properties make smart energy retrofit decisions that will result in energy savings and a cleaner environment.

Description

Initiated on April 1, 2007, the $745-million ecoENERGY Retrofit – Homes program provided federal grants to property owners for improving the energy efficiency of their homes and reducing their home's impact on the environment. Originally a four-year program, an additional one-year investment of $400 million was allocated in 2011–2012.

ecoENERGY Retrofit – Homes used NRCan's EnerGuide Rating System to help homeowners make smart energy retrofit decisions for their home. With this system, an energy advisor performs a professional evaluation of the energy efficiency characteristics of the house, including a diagnostic test to determine air leakage. The energy advisor prepares a detailed, personalized checklist of the recommended, most effective upgrades for the property owner, including the EnerGuide pre-retrofit energy rating of the house. The property owner then chooses which upgrades to have done.

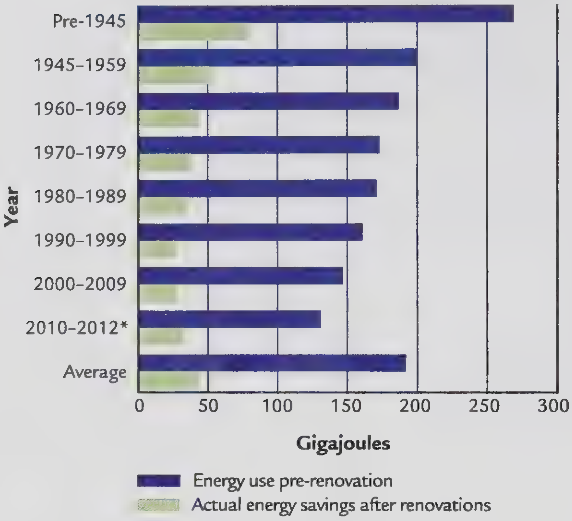
Under ecoENERGY Retrofit – Homes, after the retrofit work was completed, the advisor performed a post-retrofit energy evaluation and assigned a new energy-rating label, and the property owner was then entitled to a grant.

Along with ecoENERGY Retrofit – Homes, 12 of 13 provinces and territories offered complementary incentive programs. Five of these continue to

offer incentive programs, making ongoing use of NRCan's EnerGuide Rating System and its national infrastructure (file processing, quality assurance, technical support, software, etc.).

Figure 3-4 illustrates the energy use and savings gained per household before and after renovations.

FIGURE 3-4 Residential Energy Use and Energy Savings per Household, Pre-1945 to 2010–2012



*Data is from ecoENERGY Retrofit – Homes (previous data source was EnerGuide for Houses).

Key Program Achievements

- From 2007 to 2012, the ecoenergy Retrofit–Homes program provided incentives to more than 640 000 homeowners. As a result of this program, these homeowners are now saving over $400 million on their annual energy bills and are lowering their energy consumption by an average of 20 percent.
- This program developed the infrastructure for home energy assessments and labelling, and more than 2000 energy advisors have been trained by service organizations since the programs' inception.
- It is estimated that the ecoENERGY Retrofit–Homes program has triggered more than $8 billion in economic activity and has created and protected thousands of jobs.
- Fourteen regional organizations have developed their own energy efficiency programs for homes, and utility and municipality programs are also emerging, all of which use the EnerGuide Rating System and its energy advisors to perform energy evaluations.

ecoENERGY FOR ALTERNATIVE FUELS

Objective

ecoENERGY for Alternative Fuels is a five-year $3.0-million program that will help Canada's emerging alternative fuel industries by supporting education and outreach efforts as well as codes and standards development for natural gas.

Description

The ecoENERGY for Alternative Fuels' activities were identified in the *Natural Gas Use in the Canadian Transportation Sector Deployment Roadmap* as key areas where governments can facilitate the deployment of medium- and heavy-duty natural gas vehicles in Canada.

Education and outreach activities include establishing two local support networks that will act as information hubs for natural gas end-users (i.e. medium- and heavy-duty fleets) and other key stakeholders (e.g. vehicle and equipment manufacturers). The hubs – which are modeled after the United States Clean Cities Program – will provide "on-the-ground" resources to end-users who would like to obtain information about alternative fuelling options such as natural gas. The hubs' primary activities will be delivering education and outreach materials, responding to stakeholder inquiries and organizing workshops.

As a complement to the hubs, the program will launch a Web portal that will ensure consistent, fact-based information is available to investors, end-users and other stakeholders. To achieve this objective, the Web portal will contain information provided by a range of expert sources (e.g. natural gas suppliers, equipment providers and end-users).

In addition to education and outreach, the ecoENERGY for Alternative Fuels program will

support work on codes and standards. One area of focus will be harmonizing codes and standards for compressed natural gas vehicles and infrastructure with those of the United States and provinces. This program will also develop new codes and standards for liquefied natural gas vehicles and infrastructure.

> **DID YOU KNOW?**
>
> Canada is one of the world's largest producers of natural gas and has one of the most extensive natural gas pipeline distribution networks in the world. Canada's abundant natural gas resources can be used in all of the nation's major economic sectors, including transportation.

Key 2011–2012 Achievements

- Two codes and standards committees actively worked on developing and updating the natural gas codes and standards.
- Stakeholders were notified of the availability of new research, analysis and studies.
- Three new studies related to codes and standards were completed.

For more information:
oee.nrcan.gc.ca/alternative-fuels

ecoENERGY FOR BIOFUELS

Objective

To support the production of renewable alternatives to gasoline and diesel and encourage the development of a competitive renewable fuels industry in Canada.

Description

ecoENERGY for Biofuels provides an operating incentive to facilities that produce renewable alternatives to gasoline, such as ethanol and renewable alternatives to diesel, such as biodiesel, based on production volumes and sales. The program will invest up to $1.48 billion over nine years, starting April 1, 2008, in support of biofuel production in Canada and the *Renewable Fuels Regulations*.

This program is expected to increase domestic production capacity and develop a competitive domestic renewable fuel industry. The program targets 2.5 billion L of domestic production capacity by December 2012, specifically 2 billion L of renewable alternatives to gasoline and 500 million L of renewable alternatives to diesel fuel.

To receive an incentive, eligible recipients sign a contribution agreement with NRCan, meet the requirements of the *Canadian Environmental Assessment Act* and comply with all other applicable federal, provincial and municipal environmental legislation.

ecoENERGY for Biofuels is a key component of Canada's renewable fuel strategy, which aims to

- reduce the greenhouse gas emissions that result from fuel use
- encourage greater production of biofuels
- accelerate the commercialization of new biofuel technologies
- provide new market opportunities for agricultural producers and rural communities

> **DID YOU KNOW?**
>
> Agro-industry residues such as animal fat, restaurant cooking oil, non-food-grade virgin oil or agricultural surplus once destined for a landfill are now a commodity in the biodiesel business.

Key 2011–2012 Achievements

- As of March 31, 2012, contribution agreements were signed with all eligible producers. Together these 30 agreements represent the capacity to produce 1807 million L per year of ethanol and 494 million L per year of biodiesel by December 2012.

For more information:
oee.nrcan.gc.ca/biofuels

FEDERAL BUILDINGS INITIATIVE

Objective

To help Government of Canada organizations implement energy efficiency upgrades that lead to reduced energy and water use, greenhouse gas emissions and operating costs.

Description

The Federal Buildings Initiative facilitates energy efficiency retrofit projects in Canadian federal organizations (departments, agencies and Crown corporations).

The initiative provides tools, training, model documents (energy performance contracts, requests for proposals), advice and procurement assistance to help federal organizations develop energy management plans and use energy performance contracting to finance energy efficiency retrofits of facilities.

Other levels of government, institutions and private sector firms have drawn on the initiative's experience for help in designing their own energy efficiency programs using energy performance contracting.

Since its inception in 1991, the initiative has helped upgrade thousands of square metres of federal building floor space, saving $43 million in energy costs and reducing greenhouse gas emissions by approximately 285 kilotonnes per year.

> **DID YOU KNOW?**
>
> An energy performance contract uses private-sector dollars to pay for energy efficiency improvements. Typically, under this arrangement, an energy service company is hired to assess a facility, identify possible energy savings, recommend and implement energy efficiency improvements, and guarantee the energy savings. The energy savings pay for the cost of the retrofit over the contract period.

Key 2011–2012 Achievements

- One hundred and eighty people were trained through customized Dollars to $ense training for nine Department of National Defence air force bases across Canada.
- The National Research Council Canada was helped to finalize its energy performance contract for the retrofit of the federal laboratory located at 100 Sussex Drive, Ottawa.
- The following departments were helped to undertake opportunity assessments toward the development of energy performance projects: Natural Resources Canada, Department of National Defence (air force base in Cold Lake, Alberta), Environment Canada laboratories in Ontario, Agriculture Canada laboratory in Alberta and five Health Canada laboratories in Ontario.

For more information:

oee.nrcan.gc.ca/fbi

CHAPTER 4

Clean Energy Science and Technology

INTRODUCTION

Natural Resources Canada (NRCan) invests in research, development and demonstration of new and emerging clean energy science and technology that produces economic, social and environmental benefits for Canadians. NRCan's Office of Energy Research and Development and CanmetENERGY lead the federal government's energy science and technology operations.

NRCan, through CanmetENERGY and the Office of Energy Research and Development, undertakes and funds projects and activities in the following strategic areas:

- clean energy systems for buildings and communities
- clean electric power generation
- clean energy systems for industry
- environmentally sustainable oil and gas development
- clean transportation energy
- sustainable bioenergy

The Office of Energy Research and Development oversees the management of the Program of Energy Research and Development, the ecoENERGY Technology Initiative, the Clean Energy Fund and the ecoENERGY Innovation Initiative.

These programs collectively allocated more than $248 million in the 2011–2012 fiscal year across the six strategic areas. The funds help find new, long-term, cleaner and more efficient solutions to reducing environmental emissions by developing and disseminating new knowledge and new technologies through research, development and demonstration initiatives. The work undertaken was delivered in partnership with CanmetENERGY, other government departments and agencies and the private sector.

CanmetENERGY, with its three laboratories across Canada, generates and provides knowledge and technologies to advance the development and use of innovative solutions that contribute to the well-being of Canadians and to progress toward meeting Canada's economic, social and environmental policy objectives. It works with industry, academia, utilities, associations, non-governmental organizations and other governments to develop and demonstrate energy-efficient, alternative transportation fuels, renewable energy technologies and cleaner fossil fuels.

This chapter describes in detail the programs, activities and 2011–2012 key achievements of the Office of Energy Research and Development, CanmetENERGY and other partners in energy science and technology.

For more information:
nrcan.gc.ca/eneene/science/resres-eng.php
canmetenergy.nrcan.gc.ca/home

PROGRAM OF ENERGY RESEARCH AND DEVELOPMENT

Objective

To fund research and development designed to ensure a sustainable energy future for Canada in the best interests of its economy and the environment.

Description

The Program of Energy Research and Development is a federal, interdepartmental program operated by NRCan. The program funds research and development designed to ensure a sustainable energy

future for Canada in the best interests of both our economy and our environment.

Thirteen federal departments and agencies participate in the program:

- Agriculture and Agri-Food Canada
- Atomic Energy of Canada Limited
- Canada Mortgage and Housing Corporation
- Environment Canada
- Fisheries and Oceans Canada
- Health Canada
- Aboriginal Affairs and Northern Development Canada
- Industry Canada
- National Defence
- National Research Council Canada
- Natural Resources Canada
- Public Works and Government Services Canada
- Transport Canada

These departments and agencies may collaborate with

- the private sector
- associations
- other funding agencies such as the National Sciences and Engineering Research Council of Canada, the Industrial Research Assistance Program and Sustainable Development Technology Canada
- universities
- provincial and municipal governments and research organizations
- international organizations

Efficiencies are sought in energy production, distribution and end use.

The program budget for the 2011–2012 fiscal year was approximately $48 million. Of that amount, $13.5 million was allocated to 12 federal departments and agencies that are program partners, mostly to improve the science supporting Canadian regulations related to energy production and use. The remaining $34.5 million was allocated to energy research and development programs managed and performed in NRCan, approximately 59 percent of which contributed to improved energy efficiency and the integration of renewable energy sources in Canada.

For more information:
nrcan.gc.ca/energy/science/programs-funding/1509

ecoENERGY TECHNOLOGY INITIATIVE

Objective

To support the development of next-generation energy technologies needed to break through to emissions-free fossil fuel production, as well as for producing energy from other clean sources, such as renewables and bioenergy, and to advance the development and use of new clean energy technologies in end-use sectors.

Description

The initiative is a component of ecoACTION, the Government of Canada's actions toward clean air and greenhouse gas emissions reductions. It is a $230-million investment in clean energy science and technology. The funding helps in the search for long-term solutions to reducing and eliminating air pollutants from energy production and use. Part of the funding has been allocated to the demonstration of carbon capture and storage. Nine projects have been selected in this area. Spending in the 2011–2012 fiscal year was nearly $52 million.

Program Highlights/Achievements

- Husky Oil Operations Ltd. has started operation at their Lloydminster, Saskatchewan, upgrading facility and has started capturing carbon dioxide (CO_2) at the rate of 100 000 tonnes of carbon dioxide per year. The CO_2 will be sequestered in depleted oil wells located in Lashburn and Tangleflags, Saskatchewan.
- Enhance Energy Inc. has completed front end engineering studies and is moving ahead to implement the Alberta Carbon Trunk Line to enable the transportation of CO_2 gathered in the Alberta Industrial Heartland to enhance oil recovery at oil fields in central Alberta.

For more information:
nrcan.gc.ca/energy/science/1335

CLEAN ENERGY FUND

Objective

To fund the research, development, and demonstration of technologies, including large-scale carbon capture and storage projects and renewable energy and clean energy systems projects to reduce greenhouse gas emissions and increase the percentage of electricity produced from clean sources.

Description

The $795-million Clean Energy Fund, a component of Canada's Economic Action Plan announced in 2009, provides funding for the research, development and demonstration of promising technologies to support the Government of Canada's commitments to reducing greenhouse gas emissions. Approximately 33 percent of the 2011–2012 Clean Energy Fund was committed to or earmarked for small-scale demonstration projects, including renewable and clean energy system projects and research related to marine energy, smart grid, wind, energy storage, bioenergy, geothermal energy in the North, and community energy systems.

The Clean Energy Fund expenditures for the 2011–2012 fiscal year were approximately $110 million. Of that amount, approximately $53.7 million was allocated to large-scale demonstration projects and approximately $36.4 million was allocated to small-scale demonstration projects, which will contribute directly and indirectly to improved energy efficiency and the integration of renewable energy sources in Canada. Approximately $19.8 million was allocated to research and development.

Key 2011–2012 Achievements

- The year 2011–2012 marked the third of five years in the delivery of the Clean Energy Fund small-scale demonstrations component. In the year 2011–2012, 16 contribution agreements continued, one new agreement was signed, two projects were terminated, and two more projects continued negotiations toward an agreement. Also, to utilize unused funds, a mid-cycle call for proposals was held, which resulted in seven successful project enhancements.
- Approximately $36 million was disbursed to 17 active, small-scale demonstration projects, with more than $63 million in additional funding from the private sector, universities and other government organizations.
- More than 12 megawatts (MW) of renewable energy generation were installed in fiscal year 2011–2012, marking the first year of significant renewable energy project commissioning. Some of the systems installed included a 5-megawatt thermal (MW_{th}) biomass district heating system, part of "La Cité Verte" housing project in Québec, Quebec, and 6 MW of wind turbines in Prince Edward Island, which will be combined in the following years with energy storage technologies to manage variable wind power generation.

For more information:
nrcan.gc.ca/energy/science/programs-funding/1482

ecoENERGY INNOVATION INITIATIVE

Objective

To support energy technology innovation to produce and use energy in a cleaner and more efficient way. This initiative is a key component of the Government of Canada's actions to achieve real emissions reductions, while maintaining Canada's economic advantage and its ability to create jobs for Canadians. The ecoENERGY Innovation Initiative will also help in the search for long-term solutions to reducing and eliminating air pollutants from energy production and use.

Description

The initiative received initial funding of $97 million in Budget 2011, with additional funds of $184 million announced in spring 2012 to bring the total program funds to $281 million over five years. The initiative supports energy technology innovation to produce and use energy in a cleaner and more efficient way through research and development projects and demonstrations in five key strategic areas: energy efficiency; clean electricity and renewables;

bioenergy; electrification of transportation; and unconventional oil and gas.

Key 2011–2012 Achievements

- The ecoENERGY Innovation Initiative was launched in August 2011 with requests for letters of interest for research and development (internal and external) and demonstration projects.
- In fiscal year 2011–2012, $16 million was allocated to federal laboratories for 111 projects to be completed within the fiscal year.
- Approximately $65 million were also allocated to federal labs for 71 research and development projects that will take place between 2012 and 2016.
- The call for external demonstration and research and development letters of interest led to 246 demonstration and 436 research and development submissions. The letters of interest review was followed by a request for full proposals for those submissions that met the criteria. By the end of the 2011–2012 fiscal year, the initiative had selected 24 demonstration projects and 44 research and development projects to proceed to a rigorous review process.

For more information:
ecoenergyinnovation.nrcan.gc.ca

CLEAN ENERGY SYSTEMS FOR BUILDINGS AND COMMUNITIES

Objective

To develop, demonstrate and promote – in domestic and foreign markets – technologies, practical decision-making tools, processes, codes, standards and best practices that help communities select more efficient and cost-effective energy, waste and water technologies and design solutions to support a sustainable energy future based on reduced energy consumption and greenhouse gas emissions.

Description

CanmetENERGY plays a leadership role in the research, development and demonstration of energy-efficient and renewable energy technologies for houses, buildings and communities by

- fostering the commercialization of new technologies
- identifying and developing opportunities for the integration of energy efficiency and renewable energy technologies
- developing infrastructure to support innovation, such as codes, policies and standards
- developing links between utilities, industry and academia
- supporting training and education
- disseminating results and findings
- facilitating the export of Canadian technologies to international markets
- engaging in international co-operation

Specific work includes the development of innovative technologies, particularly integrated systems, design, modelling and analysis tools and integrated design approaches, such as building energy simulation software, making it possible to achieve greater energy efficiency to be implemented at minimal incremental costs. CanmetENERGY develops, distributes and supports building energy simulation software for the Canadian construction industry and Government of Canada programs.

CanmetENERGY is active in conceiving, developing and optimizing energy-efficient space and water heating, ventilation, air-conditioning and refrigeration technologies, heat pumps, thermal storage systems and micro co-generation systems through, for example, standards development, energy efficiency labelling, heat recovery systems, combined heat and power and energy conversion and storage systems, integration of technologies, in particular with renewables, and adaptation to the Canadian context.

CanmetENERGY assists in increasing the use of solar thermal and solar photovoltaic energy technologies in Canada by developing technologies, standards, policies and programs to create a Canadian-based, globally competitive solar industry. Other work includes community energy systems, daylighting,

intelligent building control and operation systems, and the commissioning/recommissioning of buildings.

CanmetENERGY's partnerships with industry help to build advanced residential and commercial buildings that incorporate a wide array of innovative technologies and consume significantly less energy than their conventional counterparts. Under cost-sharing arrangements to accelerate the development and commercialization of a new generation of advanced and energy-efficient technologies, CanmetENERGY is helping the Canadian residential and commercial building industry produce some of the most environmentally advanced structures on the planet.

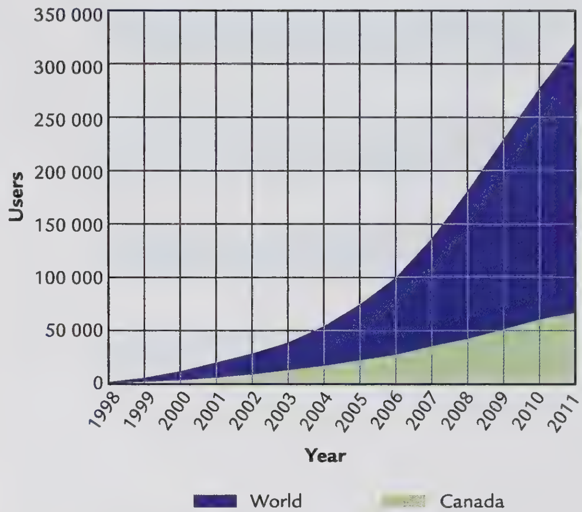
DID YOU KNOW?

Testing conducted by CanmetENERGY in 2011 at the Canadian Centre for Housing Technologies (a facility collaboratively run by NRCan, the National Research Council and Canada Mortgage and Housing Corporation) has shown that significant (>50 percent) energy savings can be achieved by using ultra-high efficiency, cold-climate, mini-split heat pump technologies in a zoned heating/cooling application, when used with a high efficiency gas fireplace as backup in the heating season. The test results have significant implications for retrofit programs.

Key 2011–2012 Achievements

- CanmetENERGY's RETScreen®[9] Clean Energy Project Analysis Software had another milestone year. The number of RETScreen users increased to more than 319 000 people in every country and territory of the world (see Figure 4-1). In addition, more than 400 colleges and universities globally are now using RETScreen for teaching and research. The new *RETScreen Plus* energy management software tool, developed in co-operation with the NASA Langley Research Center and the Austria-based Renewable Energy and Energy Efficiency Partnership, was released in 36 languages. In June 2011, the first RETScreen Conference & Training Institute was held in Niagara Falls, Ontario. This event brought together 270 key clean energy stakeholders from 40 countries.

FIGURE 4-1 RETScreen Software: Cumulative Growth of User Base



Source: NRCan/RETScreen Customer Database.

- Working to improve the reliable measurement of energy in communities, CanmetENERGY has taken a leadership role in the development of integrated community energy mapping and modeling. CanmetENERGY provided support and acted as scientific authority on the Tract and Neighbourhood Data Modelling project. Led by the Province of British Columbia, with collaboration from municipalities, utilities, academic and private sectors, the project developed a new map-based method for creating the community energy and emissions inventory reports for buildings at the neighbourhood or census-tract scale.
  - During summer heat peaks, most residential electricity is used for air conditioning. To address this, CanmetENERGY conceived a zoning strategy and partnered with private, public and academic sector organizations to develop, demonstrate and conduct a field

[9] RETScreen is a registered trademark of Her Majesty the Queen in Right of Canada as represented by the Minister of Natural Resources.

trial. CanmetENERGY partnered with the Ontario Power Authority and local utilities to consider using a zoning strategy in smart grid applications with utility-controlled thermostats similar to that currently being offered for traditional systems through the peak saver program. A statistically representative sample of field test homes has shown that air-conditioning loads can be cut by more than 50 percent during utility peaks, while providing superior comfort to the traditional peak saver approach.

- The EQuilibrium™ Communities Initiative assisted five projects in integrating their community planning and improving the energy efficiency of their buildings and energy systems. Improvements in Edmonton-based Station Pointe, for example, moved to a passive house design concept for the high-rise condominium (a first) to reduce the energy used to heat and cool buildings by over 90 percent and will now be treating the community's waste water on site.

- The commercialization of the DABO™ software developed by CanmetENERGY is performed by IFCS, a Montréal-based company. DABO is a software tool that enables continuous optimization of building operation, to achieve and maintain energy reductions while maintaining indoor comfort conditions. DABO includes modules for fault detection and diagnosis of mechanical systems and commissioning. It helps to perform commissioning and recommissioning in buildings equipped with a central control system and to maintain energy savings and corresponding greenhouse gas emissions reductions in the range of 10 to 30 percent.

- CanmetENERGY developed knowledge and expertise on CO_2 as a refrigerant or heat transfer fluid. This natural refrigerant is now largely adopted in Canadian supermarkets and is starting to be implemented in ice rinks. CO_2 has a much lower global warming potential than synthetic refrigerants and has high heat transfer properties. Its use in refrigeration helps to significantly reduce the energy consumption and greenhouse gas emissions of refrigeration systems. Sobeys recently announced that CO_2 will be the new standard for the refrigerant used in all stores of the supermarket chain. The chain has already implemented this natural refrigerant in 23 of its Quebec stores.

For more information:
canmetenergy.nrcan.gc.ca/eng/buildings_communities.html

CLEAN ELECTRIC POWER GENERATION

Objective

To develop and apply technologies for renewable electricity production and for cleaner power generation from fossil fuels, with the goal of increasing efficiency and achieving the reduction and, ultimately, the elimination of emissions of acid rain precursors, greenhouse gases, particulates and identified priority substances, such as mercury, trace elements and organic compounds.

Description

CanmetENERGY's work on clean electric power generation focuses on improving the economics and efficiency of renewable energy technologies, including wind energy, solar power, small and low-head hydro, marine energy and energy storage.

CanmetENERGY's science and technology supports the growth of the renewable energy industry in Canada by

- fostering the development of new technologies
- identifying and developing opportunities for building a "smart" power grid of renewable energy
- developing infrastructure to support innovation, such as codes, policies and standards
- developing links between utilities, industry and academia
- conducting nationwide resource assessments and mapping

CanmetENERGY also focuses on improving the performance of, and reducing emissions from, existing fossil fuel power plants. Moreover, it focuses on developing new advanced cycles for the conversion of fossil fuels to electricity with complete or near-complete capture and elimination of CO_2 and other emissions. Additional research includes work on issues associated with the transport and storage of CO_2. Through advanced tools and technologies, CanmetENERGY assists major industrial energy consumers in reducing the energy intensity of their operations and in reducing greenhouse gas emissions and emissions of other air pollutants, while enhancing competitiveness and profitability.

CanmetENERGY's work on emerging technologies in clean power includes new forms of power generation, such as wind, solar photovoltaics, small hydro, marine, natural gas combined-cycle plants and advanced fluidized bed combustion. Significant research and development also focuses on CO_2-neutral combustion systems, CO_2 sequestration, CO_2 injection for enhanced oil recovery, advanced power generation cycles, clean coal technologies and distributed energy resources. CanmetENERGY also conducts leading-edge work in the burgeoning priority area of decentralized energy resources, where renewable energy sources are becoming more localized and integrated into the main power grid.

DID YOU KNOW?

The latest (2012) edition of the *Canadian Electrical Code, Part 1,* now includes, for the first time, Section 64 on Renewable Energy Systems. This new section covers fuel cells, small and large wind power, hydrokinetic and micro-hydropower systems.

DID YOU KNOW?

One means of reducing industrial emissions of greenhouse gases, and thereby addressing climate change issues, is to incorporate carbon capture and storage technologies at large point-source industrial facilities. However, the additional cost of carbon capture and storage technologies to the industry and the efficiency penalty incurred through these technologies are major barriers to the deployment and adoption of the technologies. NRCan researchers are exploring newer designs and systems that have the potential to reduce the aforesaid costs while at the same time improving on efficiencies. If successful, these technologies would help Canadian and international industries address the global problem of climate change.

Key 2011–2012 Achievements

- CanmetENERGY was a co-chair of the national Smart Grid Technology and Standards Task Force that completed an exhaustive review of the current status and future needs of the electric power industry. The task force includes more than 50 active experts across eight stakeholder groups in Canada. The roadmap report with 17 recommendations was submitted to the Canadian National Committee of the International Electrotechnical Commission and the Standards Council of Canada. This national strategic plan will encourage the adoption of harmonized standards during a period in which Canadian provinces are investing in modernizing the electricity power system.
- CanmetENERGY's *Oxy-fuel combustion for power generation and carbon-dioxide (CO_2) capture* was published by Woodhead. This is a first of its kind publication in this technology area that highlights the research conducted at CanmetENERGY over many years and includes contributions from researchers around the world.

- Foster Wheeler, a boiler manufacturer, has successfully demonstrated oxy-combustion circulating fluid bed reactor technology at the 30-MW_{th} scale at the CIUDEN Technology Development Centre for CO_2 Capture in Spain. This success is due in part to an extensive test program conducted at the CanmetENERGY 0.8-MW_{th} fluid bed to characterize the potential design fuels and sulphur sorbents. The test was done both in air and oxy combustion modes. This program was a collaboration with CanmetENERGY and Spain's Empresa Nacional de Electricidad.
- Due in part to tests carried out at CanmetENERGY, Pratt & Whitney Rocketdyne has successfully demonstrated their compact gasification technology that uses Canadian coal and oil sands petroleum coke in collaboration with Alberta Innovates – Energy and Environment Solutions at the scale of 20 tonnes per day.
- The Marine Renewable Energy Technology Roadmap was unveiled at the Ocean Renewable Energy Group annual conference in Montréal in November 2011. Designed to secure Canada as a world leader in marine renewable development, the roadmap outlines Canada's collaborative efforts to advance the commercialization of marine energy technologies while improving its global competitiveness. More than 100 organizations contributed to the roadmap.
- In November 2011, the Drake Landing Solar Community was recognized for its innovative excellence by winning the Energy Globe World Award from the Energy Globe Foundation. The prize jury included international organizations such as the World Bank and the European Renewable Energy Council. This is a first for the department and the first time a Canadian project has achieved such a distinction. Initiated and led by CanmetENERGY, the Drake Landing project is the first large-scale, solar, seasonal storage system in North America.
- A study that examines the impact of cold climates on the electricity production from 24 wind farms in Canada was completed in 2011. This study compared the actual production output of these wind farms against a potential production based on the actual wind conditions and identified a potential lost opportunity of between 1.6 and 27.4 percent of the wind farms total potential annual production. The study also examined the technologies available to mitigate the impact of cold climates on wind farm electricity production (blade ice reduction systems), which will be the focus of future research and development.

DID YOU KNOW?

In 2011, the Canadian Photovoltaic industry drove $584 million of economic output and provided direct employment for approximately 5100 hours. Key innovative photovoltaic companies in Canada have raised more than $95 million in government and venture capital funding. In addition, private companies are dedicating more than $20 million annually for photovoltaic research and development in Canada.

Source: CanmetENERGY (2012), *Sector Profile for Solar Photovoltaics in Canada*

For more information:

canmetenergy.nrcan.gc.ca/eng/clean_fossils_fuels.html

canmetenergy.nrcan.gc.ca/eng/renewables.html

CLEAN ENERGY SYSTEMS FOR INDUSTRY

Objective

To identify, encourage and support the development and application of leading-edge, energy-efficient and environmentally responsible processes, practices, products, systems and equipment in Canadian industry to improve its energy efficiency, productivity, competitiveness and profitability, while reducing greenhouse gas emissions and other environmental impacts.

Description

CanmetENERGY works with industry to co-manage and share the costs of development and commercialization of a range of technologies, including process integration, learning-based expert systems, combustion systems and controls, manufacturing processes, and environmentally friendly and energy-efficient processes for energy-intensive industries. CanmetENERGY's science and technology in the industry sector focuses on plant-wide industrial process analysis techniques and advanced process control systems that identify and correct inefficiencies in plant operation and design while taking into account energy, economic and environmental aspects.

CanmetENERGY's science and technology also includes the development and testing of semi-pilot-scale plants, pilot plants, prototypes and full-scale field trials. This research evaluates operating performance, energy efficiency and environmental impacts and emerging concepts in chemical and energy conversion, including hydrogen production from hydrocarbon and renewable sources. In addition, CanmetENERGY disseminates technical information to encourage adoption of these techniques and practices in targeted energy-intensive sectors of Canadian industry.

CanmetENERGY clients are from a variety of industries, including pulp and paper, gas, oil upgrading and refining, petrochemicals, engine manufacturing, steel, chemicals, food and drink, solid wood, waste oil recycling and rendering, and specialty ceramic manufacturing. Its other clients are gas and electric utilities, equipment manufacturers and other governments.

Key 2011–2012 Achievements

- A catalytic converter capable of reducing nitrogen oxide emissions from diesel engines has been developed to the prototype testing phase at CanmetENERGY, with the assistance of an emission control manufacturer. Testing was completed on small diesel engines and is planned to be tested in diesel-powered mining equipment at the CANMET Mining and Minerals Sciences Laboratories. An effective catalyst capable of retrofit on mining equipment would dramatically reduce the energy expenditure and operating cost of ventilation for mines, while allowing engine designers to design for full energy efficiency.
- CanmetENERGY developed a unique optimization algorithm to redesign complex heat exchanger network in industry. This algorithm was tested as part of demonstration projects in two oil refineries, showing potential energy savings of over 20 percent in crude preheat trains of these refineries. This could result in energy savings of more than $7 million per year for these two cases. The algorithm will be made available to the industry and its consultants by the end of 2012 by being embedded in the CanmetENERGY integration software that is used to identify and evaluate heat recovery opportunities in industrial processes.
- A tool that improves recovery boiler operation, the heart of the Kraft pulp and paper process, was developed and implemented. Increased throughput and efficiency, reduced carryover and emissions as well as more stable downstream processes were obtained. As a result, a 3.5 percent increase in steam production was identified at the Fibrek mill in Saint-Félicien, Quebec. This additional steam can be used to produce 1.6 MW of additional electricity or to reduce heavy oil consumption at the plant, leading to increased revenues and competitiveness for the mill. CanmetENERGY now plans to deploy this low cost technology for the rest of the industry.

- CanmetENERGY has developed knowledge and expertise on a device known as an ejector that can produce cold from waste heat for industrial applications. The ejector uses energy from flue gases to cool incoming air for an industrial process. The free energy thus recovered from the outgoing gases improves the process and reduces the fossil fuel requirements. The technology will be deployed internationally in 2014.

> **DID YOU KNOW?**
>
> CanmetENERGY-Varennes is the national centre of expertise for process integration. Process integration is a powerful approach to optimizing energy use and power generation in industrial facilities. To date, 53 large and medium-sized companies benefit from process integration, resulting in energy cost savings of $54 million annually and a reduction in direct greenhouse gas emissions of 311 kilotonnes per year.

For more information:
canmetenergy.nrcan.gc.ca/eng/industrial_processes.html

ENVIRONMENTALLY SUSTAINABLE OIL AND GAS

Objective

To provide science and technology for the continued, secure supply of affordable, cleaner and more efficient fossil fuels, with little or no adverse environmental impact on greenhouse gas and criteria air contaminant emissions, and thereby help resolve oil sands environmental issues (including water) and clean air issues for the upstream oil and gas industry.

Description

CanmetENERGY conducts fundamental and applied research to develop knowledge and implement leading-edge technologies for the oil sands sector. Knowledge gained is used to inform energy policy development and industry decisions that will improve the quality of life for Canadians.

CanmetENERGY fosters innovation in oil sands and heavy oil technology through activities ranging from fundamental science to commercial-scale technical support. CanmetENERGY's strength lies in its staff's fundamental understanding of the chemistry, physics and engineering of oil sands and heavy oil processes, coupled with sophisticated analytical instrumentation and pilot-scale units providing proof of concept for technologies.

Science and technology is a key tool used by NRCan to make significant progress toward meeting its water and tailings, greenhouse gas and other air emissions challenges in the oil and gas sector. Major improvements need to be made in the entire process chain of oil sands and heavy oil development, from the initial extraction to the production of petroleum products.

CanmetENERGY's international client base and partnerships with provincial and territorial governments, industry and academia ensure that the best available technologies in the world can be applied to the resource. Its partnerships also ensure there are strong synergies and fast-track deployment of new technologies, innovations and knowledge dissemination.

Key 2011–2012 Achievements

- Fundamental research conducted at CanmetENERGY identified the properties behind the fast settling rates of the high-temperature froth treatment. This discovery allows for the targeting of particular conditions that will generate greater treatment efficiencies. Shell Canada began operation of the treatment technology in 2012. This treatment improves energy efficiency by 10 percent and reduces water use by 10 percent but the mechanism behind these improvements was unknown. Through CanmetENERGY's research, the properties behind these efficiencies were discovered.
- CanmetENERGY discovered a new mechanism of emulsion stabilization for the naphtha froth treatment process. This new discovery should lead

to the development of specialized demulsifiers, which enhance the removal of water/oil emulsions from the bitumen by using the naphtha process. Enhancing the removal of the emulsion will decrease corrosion and increase bitumen quality for direct pipelining. The naphtha froth treatment process is currently used by Canadian Natural Resources Limited, Suncor Energy Inc. and Syncrude Canada Ltd. oil sands operations.

- CanmetENERGY has developed analytical methods to measure solubility parameters to reduce compatibility and fouling issues and developed new methods for measuring total acid values and crude corrosivity to address pipeline and refinery corrosion concerns. Knowledge from this work was used to respond to policy, media and parliamentary questions concerning the corrosivity of transporting oil sands crude in pipelines. As well, a collaborative project with the Alberta government and industry was initiated that is using this knowledge to develop technologies to selectively remove problematic chemicals to improve oil sands crude value and reduce the environmental impacts from upgrading and refining.
- In 2012, UOP LLC announced that its new process technology was selected by National Refinery Limited in Pakistan. This new design is based on a slurry hydrocracking process previously developed by CanmetENERGY. This technology will help refiners get a higher-value product from each barrel of crude by maximizing diesel and lubricant production from petroleum residue. National Refinery Limited selected the technology to produce 40 000 barrels per day of diesel fuel and 4500 barrels per day of lube base oils.
- CanmetENERGY's researchers found and measured the extent to which chemicals similar to those that typically would be added in an oil sand operation (corrosion inhibitors, flocculants, emulsifiers and detergents) adsorb minerals and organic-coated minerals that would be found in an oil sand area. These values are the factors needed to model contaminant transport in groundwater, an important aspect in determining the sustainability of reclaimed oil sand tailings ponds.

For more information:
canmetenergy.nrcan.gc.ca/eng/clean_fossils_fuels.html

CLEAN TRANSPORTATION ENERGY

Objective

To research, develop and deploy innovative, energy-efficient and clean transportation energy technologies, with the goal of reducing transportation greenhouse gas emissions while improving urban air quality and offering economic opportunities for Canadian industry.

Description

CanmetENERGY works with domestic and international stakeholders ranging from original equipment manufacturers and associations to universities and federal departments, focusing on three principal technology areas: hybrid and electric vehicles, advanced fuels and technologies, and hydrogen and fuel cells. CanmetENERGY is actively engaged in the development of safety, codes and standards, as well as technology roadmaps related to transportation.

At this time, hybrid and electric vehicle technologies offer energy-saving advantages over current vehicle technologies that run solely on conventional fuels, such as gasoline or diesel. CanmetENERGY is supporting research and development of on-board energy-storage and power systems, such as batteries and fuel cells. Following the development of the Canadian Electric Vehicle Technology Roadmap in 2010, CanmetENERGY continues to play a significant role in coordinating stakeholders and delivering on the recommendations from the roadmap.

Research and development in advanced fuels such as natural gas, biodiesel, and ethanol and in their related technologies is strengthening Canadian industries that now include world-leading technology providers and are exporting commercial products world-wide. CanmetENERGY is also leveraging

capacity for advanced fuels and technology research through national and international collaborative efforts such as the Canadian Natural Gas Roadmap Technical Advisory Group and the Advanced Motor Fuels Agreement of the International Energy Agency.

With regard to hydrogen and fuel cell technologies, long-term investments and partnerships led by CanmetENERGY have resulted in world-leading scientific breakthroughs and demonstrations. Today, Canadian technology is used in more than 60 percent of all hydrogen and fuel cell demonstrations worldwide. Canada also exports more than 90 percent of its hydrogen and fuel cell technology. CanmetENERGY continues to support research and development in hydrogen production, hydrogen storage, fuel cell utilization and safety, codes and standards. Cost reductions, performance and harmonization of standards remain the critical goals.

DID YOU KNOW?

The British Columbia transit fleet is operating the world's largest hydrogen fuel cell-powered bus fleet. The fleet is fuelled by the world's largest hydrogen fuelling station, dispensing up to 1000 kilograms per day since it went into service in 2010.

Key 2011–2012 Achievements

- CanmetENERGY helped establish the Natural Gas Roadmap Implementation Committee, which supports the implementation of the recommendations from the *Natural Gas Use in the Canadian Transportation Sector Deployment Roadmap*, published in January 2011. In addition, CanmetENERGY is co-chairing the Natural Gas Roadmap Technical Advisory Group, which provides advice and guidance on industry, government and academic research, development and demonstration efforts.
- CanmetENERGY worked in partnership with Hydrogenics to develop a new, megawatt-scale, very compact, proton exchange membrane electrolyser stack platform that is suitable for large energy storage capacity for smart grid and renewable energy applications. Hydrogenics is a Canadian company with expertise and world leadership in designing, building and commissioning alternate energy systems. The new stack is designed to produce 570 kilograms per day of hydrogen fuel and would occupy only 0.26 cubic metres of space. The convergence of the electric distribution grid with the gas distribution and storage infrastructure opens up a new world of flexibility and adaptive capacity for energy in Canada.

For more information:
canmetenergy.nrcan.gc.ca/eng/transportation.html

SUSTAINABLE BIOENERGY

Objective

To assist Canadian industry in the research, development and demonstration of bioenergy technologies, thereby increasing the production and use of bioenergy, which generates environmental and economic benefits.

Description

CanmetENERGY supports the research, development and demonstration of bioenergy technology through cost-shared agreements, promotes bioenergy as a renewable and sustainable energy source, advocates the need for proper policies and programs relating to bioenergy, and raises the public's and policy-makers' awareness of the benefits of bioenergy.

CanmetENERGY's expertise in biomass energy conversion technology covers the following main processes:

- combustion – converting forestry, agricultural and municipal residues into heat and power under environmentally sound conditions
- gasification – converting forestry, agricultural and municipal residues into syngas
- pyrolysis – converting forestry and agricultural residues into bio-oils and value-added products

- fermentation – converting the starch and cellulose components in biomass into bio-ethanol
- transesterification – converting a variety of new and used vegetable oils, tallow and yellow grease into bio-diesel
- anaerobic digestion – converting manures and food-processing and municipal wastes into methane-rich biogas

Activities focus on improving the reliability and lowering the cost of technologies, disseminating information on technology feasibility and economics to potential users, and helping industry demonstrate its products in domestic and foreign markets.

Initiatives include research, development and demonstration, technical and socio-economic studies, end-use demonstrations and testing, feasibility studies, process analysis, verification, testing and improvement, emissions reductions, modelling, conference and workshop support, information dissemination, International Energy Agency collaboration and committees, stakeholder education, and standards development.

NRCan leads the Canadian Biomass Innovation Network, which was formed to direct federal research and development on bioenergy and bioproducts. Clients include the agricultural and forestry sectors (biomass producers and bioenergy consumers), municipalities and industrial partners.

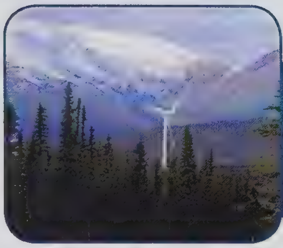
The network supports strategic research and development in bioenergy, biofuels, bioproducts and industrial bioprocesses to reduce fossil-fuel energy consumption, directly or indirectly reduce greenhouse gas and criteria air contaminant emissions.

The network is managed by Agriculture and Agri-Food Canada, Environment Canada, Industry Canada, National Research Council Canada, NRCan and the Natural Sciences and Engineering Research Council of Canada.

Key 2011–2012 Achievements

- Private industry research that has been developed through contribution agreements managed by CanmetENERGY has been used to introduce fuel gas gasifiers for application in combined heat and power in Prince George and Vancouver, British Columbia. These installations exploit local sources of woody biomass and will be evaluated for performance in real-world operation.
- Using pyrolysis oil in commercial boilers was tested at CanmetENERGY with the active participation of a pyrolysis oil producer and a burner design company (Brais Malouin and Associates, inc.). Critical parameters were identified for the combustion of the oil so that it would meet current safety and operation practice standards. As well, components that would need further improvement were identified. This represents the first controlled combustion of the oil in a commercial-scale application.

For more information:
canmetenergy.nrcan.gc.ca/eng/bioenergy.html
cbin.gc.ca



CHAPTER 5

Renewable Energy

RENEWABLE ENERGY USE

In 2010, renewable sources accounted for 17.1 percent of Canada's total primary energy supply and about 62 percent of Canadian electricity generation and total electricity-generating capacity (see Table 5-1). Most of the renewable energy used in Canada comes from either hydroelectricity or thermal energy from biomass, such as wood-waste sources, although the contribution of wind power and solar photovoltaic, the fastest growing sources of electricity in Canada, is becoming increasingly important in the national energy mix (see Table 5-2).

TABLE 5-1 Electricity-generating Capacity From Renewable Sources (Includes Hydroelectricity)

Year	Renewable electricity generation capacity (megawatts)	Total capacity (percent)	Percent change
1990	59 557	58.0	–
1991	61 116	58.0	3.0
1992	62 895	58.0	2.9
1993	63 114	56.0	0.3
1994	63 175	56.0	0.1
1995	66 542	57.0	5.3
1996	67 101	59.0	0.8
1997	68 202	61.0	1.6
1998	68 340	62.0	0.2
1999	68 614	61.8	0.4
2000	69 031	62.0	0.6
2001	68 845	61.2	-0.3
2002	71 032	61.8	3.2
2003	72 275	61.8	1.7
2004	72 947	60.4	0.9
2005	74 368	61.2	1.9
2006	75 812	61.2	1.9
2007	76 888	61.9	1.4
2008	78 419	62.4	2.0
2009	80 658	62.6	2.9
2010	80 905	62.0	0.3

Source: Statistics Canada, *Electric Power Generating Stations*

TABLE 5-2 Renewable Energy Technologies Used in Canada

Electricty – Commercial	**Mechanical power**
Hydroelectric dams	Wind water pumps
Tidal barrages	**Thermal energy**
In-stream current devices	Biomass (e.g. roundwood, pellets, wood chips)
Biomass (e.g. wood waste)	
Biogas (e.g. methane from landfill sites)	Ground-source heat pumps (i.e. earth energy)
Wind turbines	Solar air-heating systems
Photovoltaic systems	Solar hot water systems
Electricity – In development	**Transportation**
Wave systems	Biodiesel
Tidal systems	Ethanol from biomass

Hydroelectricity

Hydroelectricity is a renewable form of electricity generated from a system or technology that uses a mechanical method to capture and convert the kinetic energy of water.

Hydro is the main source of electricity in Canada, accounting for 59 percent of the electricity generated in 2010. Canada's hydro supply is dominated by large-scale projects developed by electric utilities.

Of the 75 104 megawatts (MW) of installed hydro capacity, 3461 MW come from small hydro sites (capacity less than 50 MW), representing 2.7 percent of Canada's total installed electricity capacity. Significant potential remains for additional large and small run-of-river hydroelectric development in most provinces and territories.

Biomass

Biomass provides a renewable source of energy derived from the conversion of matter from living organisms or metabolic by-products. Canada has an abundant supply of many types of biomass, which is important for the production of energy, biofuels, materials and chemicals. The two largest sources of biomass supply in Canada are forest sector and agricultural operations.

Biomass supply typically takes the following forms:

- forest sector – mill or pulp-and-paper residues, black liquor from the pulping process, forest residue, forest management thinnings and short-rotation crops
- agriculture – agricultural crops, crop residue, processing residues, algae and aquatic biomass
- other organic waste – animal waste, such as manure from feed lots, municipal solid waste and industrial wastes

Approximately 4.4 percent of Canada's total primary energy supply comes from bioenergy. In terms of renewable energy supply, bioenergy is second only to hydro power (which generates 12.3 percent of Canada's energy). Most of the bioenergy produced is in the form of industrial process heat, electricity and residential space heating.

The pulp and paper and forest industries are Canada's major producers and users of bioenergy. In 2010, 685 MW of biomass generating capacity came from spent pulping liquor used in the pulp and paper industry. This amount represents approximately 40 percent of the total biomass generating capacity, while 51 percent of the capacity (868 MW) came from wood refuse used by the forest industry.

Heat and electricity produced by industry, electricity generated by independent power producers and residential wood heat are considered commonplace in Canada's energy mix. For example, approximately 3 million Canadian households use wood for home heating. Roundwood is typically used but alternatives include wood chips and pellets. Wood for home heating is usually burned in stand-alone wood stoves, wood furnaces with hot water or forced-air systems, fireplaces with advanced combustion inserts, high-efficiency fireplaces or high-thermal-mass masonry heaters.

Use of biogas and landfill gas (methane-rich gases that are derived from manure, animal processing wastes, other agricultural residues and municipal waste) for energy production is just emerging.

In 2010, the biomass installed generating capacity was 1700 MW, of which 8.6 percent was from landfill gas plants (112 MW) and municipal solid waste plants (35 MW). Approximately 200 million litres of fuel ethanol are produced annually in Canada from cereal grain and corn. Biodiesel is also produced in small quantities, but production is increasing. Canada has the potential to increase its bioenergy production in a sustainable manner.

Earth Energy

As a result of the sun heating the surface of the planet, and because of the insulating qualities of the earth itself, the temperature 1 or 2 metres (m) below the surface remains fairly constant – between 5°C and 10°C. This temperature is warmer than that of the air during the winter and cooler than that of the air in the summer.

Geothermal energy can be used as a heat source or sink for heating or cooling applications, such as ground-source heat pumps. The pumps are electrical systems that use the relatively constant temperature of the ground to provide heating, cooling and hot water for homes and commercial buildings.

For this reason, a ground-source heat pump is also known as an earth energy system. During winter, earth energy systems remove heat from the earth by using a liquid, typically an antifreeze solution or water, that circulates within an underground loop. The system then upgrades the heat with a

conventional heat pump and transfers it to indoor space or the water-heating system. During summer, the system reverses this process to operate as an air conditioner. Earth energy systems supply less than 1 percent of the market for space and water heating and cooling in Canada.

In 2010, approximately 11 265 ground-source heat pumps were installed in Canada. This is roughly 28 percent less than the 15 640 pumps installed in 2009. As of December 31, 2010, more than 95 000 pumps were in operation in Canada, representing about 1045 megawatts of thermal energy (MWth) of installed capacity and producing an estimated 1420 gigawatt-hours equivalent annually.

Wind Energy

Wind turbines convert the kinetic energy of wind into electrical or mechanical energy. Canada's land mass and coastal waters combine to provide a wind resource with potential estimated at more than 100 000 MW.

As of December 31, 2011, 5265 MW of wind power had been installed in Canada. This makes Canada the country with the ninth largest installed wind energy capacity.

The best year in terms of wind power installations was 2011, with 1298 MW of new wind power generating capacity installed across the country, representing a 33 percent increase from the 2010 level (3967 MW) (see Figure 5-1). In fact, Canada ranks the sixth in the world in terms of new installations in 2011. Federal and provincial policies continue to spur growth in the Canadian wind industry.

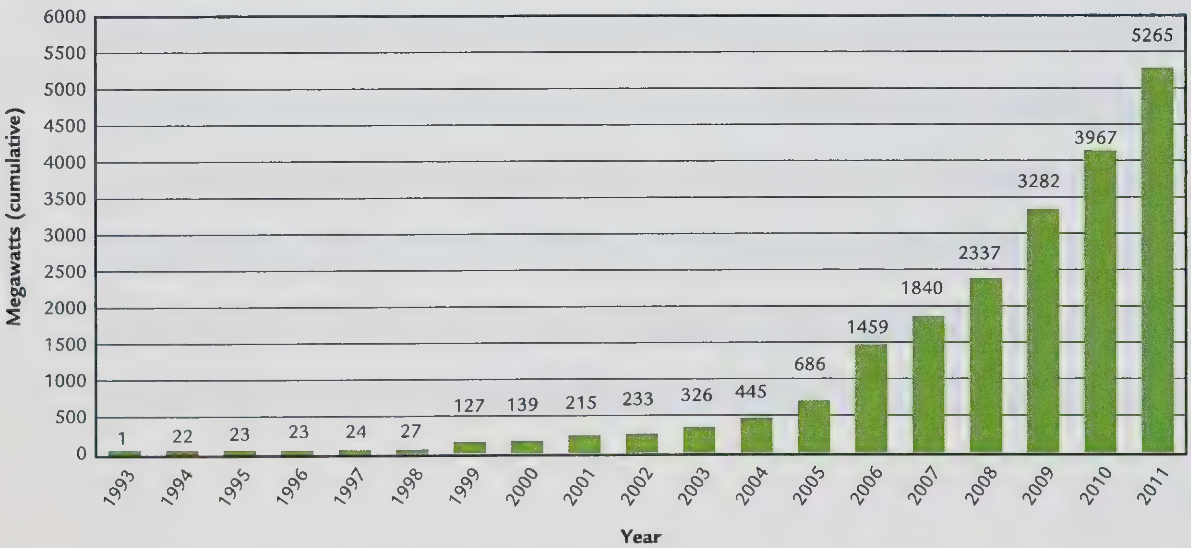
Wind energy also provides mechanical power. Several thousand wind-powered water pumps are used throughout Canada, mostly in the Prairie provinces. As well, Canadians use small, residential-sized wind turbines to power cottages and remote houses.

Solar Energy

Three main technologies use energy from the sun:

- passive solar technologies – buildings are designed and located to maximize their reception of solar energy
- active solar thermal systems – solar radiation is converted into thermal energy for heating air or water in residential, commercial and industrial applications

FIGURE 5-1 Canadian Wind Power Capacity, 1993 to 2011 - cumulative



Source: Natural Resources Canada and the Canadian Wind Energy Association

- solar electric (photovoltaic) systems – solar radiation is used to produce electricity

The Canadian active, solar thermal installed capacity in 2011 was 1 184 830 m^2, which is approximately 820 MW_{th}. The domestic market increase has averaged over 20 percent annually since 1998. In 2011, the solar thermal collector market in Canada was approximately 163 435 m^2, approximately 18 percent fewer installations than in 2010 (199 490 m^2).

Solar photovoltaic energy also experienced high rates of capacity growth – about 40 percent average growth rate annually between 1992 and 2011 – even though it started from a low baseline. So far, 2011 has been the best year for solar photovoltaic energy, with an estimated total installed capacity of 495 MW, representing an increase of 204 MW from the previous year. This significant growth was spurred primarily by two programs from the Government of Ontario: a renewable energy standard offer program launched in 2006 and the feed-in tariff program launched in 2009.

Ocean Renewable Energy

Ocean renewable energy refers to the use of ocean waves, current and tides to generate electricity. Devices that capture ocean or tidal currents can also be deployed in rivers and streams.

Since 1984, Canada has had the only commercial tidal energy facility in North America – the 20-MW plant in Annapolis, Nova Scotia. However, like wave and current devices, the next generation of tidal power generators is in an early stage of development, and as yet no commercial facilities have been proposed.

British Columbia and Nova Scotia are taking steps to support the development of the next generation of ocean renewable energy technologies, which use waves, ocean currents and tides to generate electricity.

In 2010, the Fundy Ocean Resource Centre for Energy, a technology demonstration facility, started testing three technologies with a total capacity of 4 MW. Wave and tidal-current technologies are also being tested off the coast of British Columbia, and a commercial facility for generating electricity may be feasible within the next decade.

Canada is well-poised to become a leader in global technology development and deployment. Canadian technology developers are planning and testing devices, and several demonstration projects are underway.

MARINE RENEWABLE ENERGY ENABLING MEASURES PROGRAM

Objective

The objective of the Marine Renewable Energy Enabling Measures program is to draft a federal policy framework for administering marine renewable energy activity in the federal offshore by fiscal year 2015–2016.

Description

The program will propose a policy framework to the Government of Canada on the future administration of marine renewable energy in the federal offshore.

The first of two phases of the program will research and analyse Canada's policy instruments, including relevant legislation and regulations, consult with stakeholders, and examine international marine renewable energy management regimes. The information gathered will help develop a policy paper. The paper will also highlight issues that need to be addressed to develop an efficient and effective policy framework for administration.

The second phase will consult further with stakeholders on the policy paper and develop a policy framework for the government's approval.

Key 2011–2012 Achievements

- Identified, developed and attained initial legal opinions of governance model options.
- Examined marine regulatory regimes in eight countries.
- Initiated informal consultations within Natural Resources Canada, the Department of Fisheries and Oceans, and the National Energy Board.

PULP AND PAPER GREEN TRANSFORMATION PROGRAM

Objective

The Pulp and Paper Green Transformation Program has accomplished its objective of improving the environmental performance of Canadian pulp and paper mills.

> **DID YOU KNOW?**
>
> The Pulp and Paper Green Transformation Program and the Transformative Technologies Program of Natural Resources Canada provided the funding for the Biogas Production from Mill Effluent Streams project of AV Cell Inc. in Atholville, New Brunswick. The project demonstrates the advantages of product diversification for pulp and paper mills. In collaboration with FPInnovations, the mill installed innovative, new technologies for the production and capture of biogas from mill effluent streams. This biogas can be burned to generate power, thereby replacing the use of fossil fuels.

Description

The $1-billion program operated from June 2009 to March 31, 2012, and supported environmentally friendly investments in Canada's pulp and paper industry in areas such as energy efficiency and renewable energy production. The program funded 98 projects at 43 mills across Canada, supporting approximately 14 000 jobs. The program was highly successful, with more than 99 percent of available funding being used by pulp and paper companies for a variety of projects that have significant environmental benefits.

Key Achievements

Projects funded under the program

- added nearly 200 MW of renewable electrical capacity
- produced enough renewable thermal energy to continuously heat 70 000 homes
- produced energy savings equivalent to the energy used to heat all of the houses in the city of Québec on an ongoing basis
- reduced the direct greenhouse gas emissions of the Canadian pulp and paper sector by over 10 percent from 2009 levels (because of reduced use of fossil fuels on mill sites)
- reduced mills' water use by nearly 11 million cubic metres per year – the amount of water needed to fill 4000 Olympic-sized swimming pools

> **DID YOU KNOW?**
>
> Pulp and Paper Green Transformation Program projects are expected to reduce the Canadian pulp and paper sector's consumption of Bunker C (heavy) oil by 40 percent!

For more information:
cfs.nrcan.gc.ca/pages/231

INVESTMENTS IN FOREST INDUSTRY TRANSFORMATION

Objective

The Investments in Forest Industry Transformation program supports Canada's forest sector in becoming more economically viable and environmentally sustainable through targeted investments in innovative technologies.

Description

The program is providing $100 million over four years for projects that implement new technologies that lead to non-traditional, high-value forest products and renewable energies. By building on the success of previous federal investments in research and development, the program ensures that promising breakthrough technologies in the forest sector continue to evolve toward full commercial viability.

Key 2011–2012 Achievements

- The program's second and final call for proposals, which closed in September 2011, received 57 applications representing $1.2 billion in project proposals. Nearly $300 million were requested.
- The response to the program's calls for proposals demonstrates significant appetite within the Canadian forestry sector for implementing highly innovative technologies; almost 30 percent of the projects proposed were world-first applications of new technologies.
- Renewable bioenergy is an important area for technology investments in this sector. Fifty percent of the applications were for bioenergy-related projects, including cogeneration, torrefaction, gasification and pyrolysis.
- The program supported four first-in-Canada projects in 2011–2012, which represents $26 million invested since the program's inception in 2010.

DID YOU KNOW?

The Investments in Forest Industry Transformation program contributed $2.11 million to install a Turboden Organic Rankine Cycle system that will turn biomass-based waste heat into power at the Nechako Lumber Co. Ltd. mill in Vanderhoof, British Columbia. This is the first project of its kind in a Canadian mill, with potential to inspire significant replication across the sector. In fact, the technology provider, Pratt & Whitney Power Systems, has already announced plans for two similar systems at another forest products site in British Columbia.

For more information:
forest-transformation.nrcan.gc.ca

CHAPTER 6

Co-operation

INTRODUCTION

This chapter describes Natural Resources Canada's (NRCan's) co-operation with provincial and territorial governments and internationally on energy efficiency, alternative transportation fuels and renewable energy during the reporting period. Examples of program co-operation on specific initiatives are included in the Key Achievements sections of earlier chapters.

There are two national consultative bodies in the area of energy efficiency: the Steering Committee on Energy Efficiency, established under the Energy and Mines Ministers' Conference, and the Office of Energy Efficiency's (OEE's) National Advisory Council on Energy Efficiency.

Municipal governments and agencies participate in NRCan's energy efficiency, alternative transportation fuels and renewable energy measures as clients (for training workshops, as recipients of financial incentives, etc.) and as partners (e.g. in idle-free projects). At the same time, NRCan participates in ventures led by municipal organizations, such as the Green Municipal Fund (see accompanying textbox), and by provincially and territorially regulated electricity utilities and provincially regulated natural gas utilities.

For alternative fuels, there is a Natural Gas Roadmap Implementation Committee that consists of a range of industry stakeholders who are uniquely positioned to guide the implementation of the roadmap's specific recommendations.

Internationally, Canada engages bilaterally with key partner countries and multilaterally with a number of international organizations focused on energy efficiency, alternative transportation fuels and renewable energy. This collaboration is detailed in this chapter.

Green Municipal Fund

The Government of Canada endowed the Federation of Canadian Municipalities, a non-profit organization, with $550 million to establish the Green Municipal Fund to provide a long-term, sustainable source of funding for municipal governments and their partners. The fund invests in plans, studies and projects that offer the best examples of municipal leadership in sustainable development and that other Canadian communities can replicate.

Under the fund agreement, the Government of Canada (represented by NRCan and Environment Canada) participates in governing this revolving fund, along with representatives from the public and private sectors, including municipal officials and technical experts, through a peer review committee and an advisory council.

The federation's board of directors approves projects in light of the council's recommendations. As of March 31, 2012, the federation has committed $613 million to support 934 green initiatives across Canada. Note that these are net amounts (approvals minus withdrawals and cancelled projects).

More details can be found in the *Green Municipal Fund Annual Report 2011–2012* at fcm.ca/home/about-us/green-municipal-fund-council/annual-reports.htm.

Natural Gas Roadmap Implementation Committee

NRCan facilitated the development of a deployment roadmap for natural gas use in the Canadian transportation sector, which was released in January 2011. Working in partnership, governments at all levels, industry and academic and non-governmental organizations identified opportunities and challenges associated with deploying natural gas vehicles. The roadmap includes 10 recommendations in four key areas: de-risking investment and early adoption; addressing information gaps; increasing capacity to sustain markets; and ensuring on-going competitiveness.

After the roadmap was released, the Natural Gas Roadmap Implementation Committee was established with representatives from a range of industry stakeholders who are uniquely positioned to guide the implementation of the roadmap's recommendations. The committee supports implementing the recommendations and assesses progress against key milestones. The committee recommends to stakeholders how the natural gas community could respond to future developments, such as changes in market conditions and technological innovations.

The committee oversees an outreach and education working group and a technical advisory group. The groups

- facilitate creating a Web site about alternative transportation fuels and two local support networks that will deliver education and outreach materials to fleets and other stakeholders
- work in partnership with key stakeholders on codes and standards for alternative fuel vehicles and infrastructure with the goal of enhancing the capacity within the standards community to harmonize, align and update the codes and standards

FEDERAL-PROVINCIAL-TERRITORIAL CO-OPERATION

There is continuing interest in energy efficiency as a powerful means of maximizing the services obtained from Canada's existing energy supply capacity. In addition to general co-operation on energy efficiency, provincial and territorial governments helped to deliver or employ tools provided by federal energy efficiency, alternative transportation fuels and renewable energy programs to reduce energy costs, address climate change, increase competitiveness, improve air quality and create economic opportunities. Coordination between the federal and provincial/territorial levels has aided all parties in avoiding duplication and ensuring efficient program delivery.

Energy and Mines Ministers' Conference

The annual Energy and Mines Ministers' Conference is the primary forum for federal, provincial and territorial ministers to discuss shared challenges and priorities affecting the energy and mining sectors in Canada.

In 2007, the Energy and Mines Ministers' Conference released *Moving Forward on Energy Efficiency in Canada: A Foundation for Action*. This document highlighted the value of reducing energy waste, while recognizing the vital role that governments can play in advancing energy efficiency as investors in programs and as policy-makers and regulators who help shape the marketplace by reducing barriers to action.

At the 2011 conference, ministers approved a *Collaborative Approach to Energy* and its associated action plan. The focus on a balanced supply-demand approach to energy demonstrates the importance of energy efficiency within a broader suite of energy policies. More specifically, the action plan provided concrete examples of planned federal, provincial and territorial government collaboration:

- Publish a more stringent model energy code for buildings and commit to a cycle of further improvements.

- Collaborate on a next-generation home energy rating system to support labelling, codes and incentives.
- Improve the energy efficiency of energy-using products purchased by Canadians.
- Strengthen business capacity to finance energy efficiency projects in the built environment.
- Advance the energy efficiency of freight transportation in Canada.
- Improve industrial energy performance by adopting the ISO 50001 Energy Management Systems standard.
- Collaborate with the goal of identifying and implementing new trends in integrated community energy planning.

STEERING COMMITTEE ON ENERGY EFFICIENCY

Established in 2004 under the auspices of the Energy and Mines Ministers' Conference, the Steering Committee on Energy Efficiency is tasked with establishing a coordinated, complementary agenda for energy efficiency in the built environment and equipment, industry and transportation sectors. In fiscal year 2011–2012, the federal, provincial and territorial members of the committee met to discuss issues related to energy efficiency across their respective jurisdictions.

The committee's work is coordinated by three working groups that operate under its auspices and respond to the direction of energy ministers. These working groups develop concrete energy efficiency initiatives consistent with the themes and ideas of federal, provincial and territorial ministers:

- The Built Environment and Equipment Working Group, formed in 2003 has established a dialogue on the built environment and equipment sectors among NRCan, provincial and territorial governments and agencies, utilities, industry and non-governmental organizations. This dialogue enhances the alignment of built environment and equipment strategy among jurisdictions.
- The Transportation Working Group on Energy Efficiency, formed in 2005, improves energy efficiency in Canada's transportation sector by enhancing the alignment of transportation energy efficiency activities among federal, provincial and territorial jurisdictions. It also seeks opportunities for further collaboration and new initiatives.
- The Industry Working Group on Energy Efficiency, formed in 2006, promotes the exchange of information among industrial energy end-users and authorities, agencies, utilities, and jurisdictions involved in the design, development and delivery of industry energy efficiency programs in Canada.

Following the 2011 Energy and Mines Ministers' Conference, the committee met to establish the work plans of the three working groups for 2011–2012 and began work on an integrated energy efficiency paper to serve as follow-up to the 2007 *Moving Forward on Energy Efficiency in Canada: A Foundation for Action*. This paper was released at the 2012 Energy and Mines Ministers' Conference in September 2012.

Building Energy Codes Collaborative

The Building Energy Codes Collaborative is a federal-provincial-territorial committee supported by the Energy and Mines Ministers' Conference, the Steering Committee on Energy Efficiency and NRCan. The collaborative comprises representatives from provincial/territorial code and energy ministries, departments and agencies; NRCan; and the Canadian Codes Centre. The collaborative's objectives are as follows:

- provide a forum for provinces, territories and the Government of Canada to support the update, regulatory adoption and implementation of the National Energy Code of Canada for Buildings, by responsible authorities
- work in co-operation with the provinces and territories and the Canadian Commission on Building and Fire Codes toward a national consensus on establishing energy efficiency in the code process
- explore other regulatory and/or program instruments for increasing energy efficiency in new housing, including updating the Model National Energy Code of Canada for Houses 1997

In 2007, the Canadian Commission on Building and Fire Codes approved the plan submitted by NRCan and the collaborative for updating the 1997 code. The National Research Council of Canada updated the code and NRCan provided $4 million and technical expertise. Revision took four years and the National Energy Code of Canada for Buildings was published in 2011 in an objective-based format. It complements objective-based model national construction codes issued in 2010.

Federal-Provincial-Territorial Smart Grid Working Group

The 2011 Energy and Mines Ministers' Conference action plan also tasked an intergovernmental Smart Grid Working Group to investigate the role of smart grids as a critical energy technology for enabling Canada's transition to a lower-carbon emission economy.

This working group relied on the collaborative efforts of provincial ministries and NRCan to develop a smart grid reference manual, a jurisdictional scan of smart grid projects across the country and a synthesis report that would highlight key Canadian issues in smart grids. The working group also outlined four recommendations in advance of the 2012 Energy Mines and Ministers Conference. NRCan's Office of Energy Research and Development served as the secretariat to this working group and CanmetENERGY contributed content to the jurisdictional scan and reference manual.

National Advisory Council on Energy Efficiency

An important source of strategic advice on matters related to energy efficiency is the National Advisory Council on Energy Efficiency. Created in 1998 as an innovative government organization, it provides the OEE with a broad range of opinions on all matters related to energy efficiency, connecting the OEE to the latest innovation and thinking in the field. The council fulfills its functions by

- assessing and advising on the OEE's strategic approach to meeting federal policy objectives
- advising the OEE on its performance, business planning and reporting on progress
- considering issues related to accelerating growth in energy efficiency in the Canadian economy
- developing new measures to increase the impact and reach of NRCan's energy efficiency and biofuels programs and activities

Council membership is drawn from across Canada. It includes representatives from various levels of government, academia, economic sectors, energy utilities and non-governmental organizations. The council met twice during the 2011–2012 fiscal year to advise and guide the OEE on the most effective way to achieve its mission.

All provinces and territories engage in energy efficiency activities and/or deliver energy efficiency, alternative transportation fuels and renewable energy programs in their jurisdictions. In some provinces and territories, specific organizations are mandated to promote energy efficiency. Examples include the following:

- The Manitoba Hydro Power Smart program is widely recognized for its effective, user-friendly tools for homeowners, businesses and industry to boost energy efficiency and significantly reduce energy costs.
- The Ontario Power Authority's Conservation Bureau provides leadership in planning and coordinating measures for electricity conservation and load management.
- The Yukon Energy Solutions Centre is a service and program delivery agency for federal and Yukon government programs on energy efficiency and green power.
- Efficiency NB promotes energy efficiency measures across the residential, community and business sectors of New Brunswick, developing and delivering programs and initiatives to achieve this objective.

All provinces have been promoting the use of renewable energy through various incentives, including voluntary renewable energy targets and legislated renewable portfolio standards, and procurement of renewable energy through requests for proposals, standard offer and feed-in tariff programs.

Use of Federal Program Tools by Utilities, Provinces and Territories

Provincial and territorial governments and utilities use federal energy efficiency, alternative transportation fuels and renewable energy program tools to complement their own energy efficiency programs. Here are some examples:

- Homeowners in all regions of Canada, except one territory, were able to access both provincial/territorial and federal home retrofit programs through a single energy evaluation offered under ecoENERGY Retrofit – Homes. The ecoENERGY evaluation and its criteria are also used by these jurisdictions to determine eligibility for incentives. Five provinces have ongoing incentive programs that use NRCan's EnerGuide Rating System.
- Canadians in many provinces and territories can benefit from rebates and sales tax exemptions on selected ENERGY STAR qualified products. The ENERGY STAR® Initiative in Canada is administered by the OEE and is used by several provinces and utilities as a qualifying criterion.
- NRCan's R-2000 Standard is used by utilities in Manitoba, New Brunswick and Nova Scotia as a qualifying criterion for incentives and rebates designed to encourage the construction of energy-efficient new homes.
- NRCan's EnerGuide Rating System has been used in seven Canadian jurisdictions to develop or implement energy performance requirements in their building codes or municipal bylaws.
- All the provincial and territorial government bodies responsible for driver education, except Nunavut, use the Auto$mart Driver Education Kit, developed by the OEE, to educate young drivers on fuel efficiency. For example, Manitoba Public Insurance and the Province of Ontario have recently incorporated a component on fuel efficiency into their driver education curricula. Also, many provinces display the OEE's publications in their motor vehicle licensing bureaus.

Co-operation Agreements

NRCan's memorandum of agreement on energy efficiency, alternative transportation fuels and renewable energy with the Agence de l'efficacité énergétique du Québec (now Bureau de l'efficacité et de l'innovation énergétiques du Québec) provided for the two governments to consult and share information, co-ordinate activities in Quebec, and create opportunities for joint projects. Furthermore, the management committee established under the agreement reviews policy and program developments, progress on joint program initiatives and areas for further co-operation. NRCan is working with the Bureau de l'efficacité et de l'innovation énergétiques du Québec to deliver services under the ecoENERGY programs.

The agreement played a role in facilitating three activities in particular:

- managing the licensing agreement for local delivery of ecoENERGY Retrofit – Homes
- continuing to process payments by the OEE's Buildings Division for the former EnerGuide for Existing Buildings program. Though the program is now closed, payments, which can be made only when the client verifies that work has been completed, are still being processed.
- signing a three-year collaboration agreement with CanmetENERGY to help refrigerated facilities (ice and curling rinks, supermarkets, warehouses) reduce their energy consumption and greenhouse gas emissions through the Programme d'optimisation en réfrigération. This program is based on the CoolSolution[10] approach developed by CanmetENERGY. CanmetENERGY provides technical support and training for consultants and decision makers.

NRCan has entered into several contribution agreements over the years with the Yukon Energy Solutions Centre in Whitehorse on projects related to energy efficiency. The centre provides technical services and programs for the Yukon population and undertakes outreach and public education activities.

NRCan promotes energy efficiency and renewable energy with the provinces and territories. Notable collaborations include working with the following:

- the Manitoba Office of the Fire Commissioner, which is a special operating agency of Manitoba Labour and Immigration, to engage Manitoba stakeholders in a review of the Manitoba Energy Code Advisory Committee recommendations to establish minimum code requirements for energy and water efficiency in new and renovated Part 3 buildings in the province
- Efficiency NB, Conserve Nova Scotia (now Efficiency Nova Scotia) and the Office of Energy Efficiency of Prince Edward Island, which have agreed to collaborate on a study that will establish a baseline that depicts the current state of the energy performance of new commercial buildings in these provinces
- Efficiency NB to facilitate access to the ecoENERGY Retrofit – Small and Medium Organizations program by the owners of small and medium-sized buildings
- the Canadian Standards Association to develop Canada's first edition of the new national standard on commissioning of buildings
- the Ontario Ministry of Municipal Affairs and Housing to investigate next steps required for construction sector compliance with the 2011 National Energy Code of Canada for Buildings and investigate the costs, enforcement and industry-capacity impacts of the code
- Productivity Alberta, industry associations and utilities to provide energy management training to companies across Canada through Dollars to $ense workshops
- Climate Change Central (now named C3), a non-profit corporation in Alberta funded by several stakeholders, including the Government of Alberta, which focuses on information and action on energy efficiency and conservation in the province

[10] CoolSolution is an official mark of Her Majesty the Queen in the Right of Canada as represented by the Minister of Natural Resources.

Sustainable Development Technology Canada – NextGen Biofuels Fund™

The NextGen Biofuels Fund™ is a $500-million program scheduled to run from 2008 to 2017. Responsibility for the program is held jointly by NRCan and Environment Canada. The fund is managed under the auspices of Sustainable Development Technology Canada.

The NextGen Biofuels Fund™ facilitates establishing first-of-a-kind, large, demonstration-scale facilities for the production of next-generation biofuels and co-products in Canada; improves the sustainable development impacts arising from the production and use of biofuels; and encourages retention and growth of technology expertise and innovation capacity for the production of next-generation biofuels.

Next-generation renewable fuels are derived from non-traditional renewable feedstocks – such as forest biomass, fast-growing grasses and agricultural residues – and are produced with non-conventional conversion technologies. An eligible project must use feedstocks that are or could be representative of Canadian biomass, and the technology must have been demonstrated at the pre-commercial pilot scale. Sustainable Development Technology Canada supports up to 40 percent of eligible project costs.

In 2011–2012, Sustainable Development Technology Canada approved funding for the front-end development phase of one project, assessed two other applications and received two indications of interest. Together these five key projects would represent a total investment of $467.5 million.

Atlantic Energy Gateway

The Atlantic Energy Gateway initiative was a joint initiative of NRCan and the Atlantic Canada Opportunities Agency aimed at facilitating co-operation among Atlantic provinces toward the development of the region's clean energy resources.

In 2011–2012, eight collaborative research studies were commissioned and completed. The studies provide insight into the challenges and opportunities involved in maximizing the benefits of developing clean energy in the Atlantic region.

INTERNATIONAL CO-OPERATION

NRCan co-operates with several international organizations in energy efficiency, alternative transportation fuels and renewable energy program areas and supports bilateral and/or multilateral co-operation in these areas with countries and regions such as the United States, China, the European Union, India, Mexico and Russia.

Canada benefits from this co-operation by

- learning about improved ways of designing and delivering energy efficiency, alternative transportation fuels and renewable energy programs to meet policy objectives
- working with others on the harmonization of energy efficiency tests and performance standards to reduce barriers to trade in energy-using products
- sharing Canadian tools and expertise with other international partners to achieve common environmental and energy security goals

DID YOU KNOW?

Canada is considered a world leader in energy efficiency. The International Energy Agency found that Canada was second only to Germany in its rate of energy efficiency improvement among 16 major energy-using countries, over the 1990–2008 period. Canada has a severe climate, energy-intensive economic structure and a small, highly-dispersed population, which makes it especially challenging to reduce energy use. Nevertheless, Canada continues to make significant gains in comparison to countries such as the United States, the United Kingdom, Japan and Denmark, which face some, but not all of these circumstances.

International Energy Agency

The International Energy Agency, based in Paris, France, is an autonomous agency of the Organisation for Economic Co-operation and Development. The agency runs a comprehensive program of energy co-operation among its 28 member countries, including Canada. Agency member governments have committed to sharing energy information, coordinating energy policies and co-operating on the development of national energy programs that address energy security, economic development and environmental protection. The agency and its governing board are helped by several standing groups and special committees, which bring together energy specialists from member countries.

The Standing Group on Long-term Co-operation is the key agency committee on the policy side. The standing group

- analyses policies to promote conservation and the efficient use of energy
- analyses measures to increase long-term energy security while protecting the environment
- monitors energy developments in member countries
- makes recommendations on energy policy through a regular series of individual country reviews, including the *Energy Policies of IEA Countries – Canada – 2009 Review*, which was released in April 2010

The standing group's Energy Efficiency Working Party provides advice on and direction to the agency's work on specific energy efficiency issues. The OEE represents Canada on the working party. In 2011, the agency released a report that recognized Canada as one of the top five agency member countries that has fully or partially implemented the agency's recommendations on energy efficiency.

Canada's international energy research and development objectives are mainly advanced through the agency's working parties, implementing agreements and experts groups that are under the Committee for Energy Research and Technology. The Government of Canada is committed to the agency and is an active member that fully supports its mandate to ensure reliable, affordable and clean energy for its 28 member countries and beyond. NRCan continues to support the structure, purpose and intent of the agency's four main areas of focus: energy security, economic development, environmental awareness and engagement worldwide. NRCan contributed $807,000 to agency implementing agreements in 2011–2012. Co-operation through implementing agreements has helped to accelerate technology development and set the stage for technology deployment in Canada, generating benefits that far outweigh the direct costs of collaboration. One such agreement is the agency Implementing Agreement for a Co-operating Programme on Efficient Electrical End-use Equipment. This agreement brings together energy efficiency policy-makers from Asia, Europe and North America to support policy development in the field of efficient appliances and equipment (e.g. solid state lighting, electric motor systems and standby power).

Canada also co-operates with research centres in agency member countries on several research and development and technology agreements and programs outside the agency. NRCan, together with Foreign Affairs and International Trade Canada, facilitates research and development and commercial business ventures abroad by Canadian firms by undertaking a wide variety of activities. These activities include participating in various agency tasks and supporting technical and trade-oriented workshops and conferences.

CanmetENERGY was named the operating agent of the new agency Annex 54, Integration of Micro-generation and other Energy Related Technologies in Buildings. The research program will focus on improved models of poly-generation and/or hybrid-type micro-generation systems. The purpose is to better assess the application of these systems, to identify the impact on energy use and greenhouse gas emissions and to investigate the competitiveness of these micro-generation systems in relation to other technologies. Participants are from 14 countries in Europe, Asia, Japan and North America and represent 36 research organizations, academia and private companies.

Canada participates in the agency Implementing Agreement on Heat Pumping Technologies (end-use technologies), the agency Heat Pump Program. CanmetENERGY is chairing the program, which includes 14 counties. The program objective is to increase the adoption of heat pump technology in buildings and industries for heating, cooling and refrigeration applications, thereby reducing energy use and greenhouse gas emissions. Program activities include an information service performed by the Heat Pump Centre in Sweden, international collaborative projects (annexes) in research and development, demonstration, deployment, workshops, analysis studies and a triennial conference. The next International Energy Agency Heat Pump Conference will be held in Montréal, Quebec, in 2014, organized by the Canadian GeoExchange™ Coalition, with the support of NRCan.

CanmetENERGY is participating in

- Annex 34 - thermally driven heat pumps for heating and cooling
- Annex 35 - application of industrial heat pumps with LTE-Hydro-Québec
- Annex 38 - solar and heat pump systems

In early 2012, NRCan and the Korea Institute of Energy Research reinstated the memorandum of understanding between the two organizations. Under this, CanmetENERGY developed two joint, multi-year projects with the institute and the Korean Ministry of Knowledge Economy. The projects focus on simulations, technology development and laboratory studies of highly integrated and efficient advanced hybrid microgeneration energy systems and their optimal integration into housing, buildings and communities. The institute intends to demonstrate the systems developed under these projects during the 2018 Olympic Winter Games, hosted by Korea in their "CO_2-free Olympic Village."

Canada also participates in the agency's Implementing Agreement for Renewable Energy Technology Deployment. Created in 2005, the agreement is a policy-focused, technology cross-cutting platform that brings together the experience and best practices of some of the world's leading countries in the renewable energy area with the expertise of renowned consulting firms and academia. The mandate of the agreement is to examine topical issues that influence the use of renewable energy and to help accelerate the market introduction and deployment of renewable energy technologies. The agreement informs decision makers and other stakeholders by undertaking studies and delivering reports, and it gathers strategic information by organizing and attending international events on related issues. A list of completed and ongoing projects and events is available on the agreement Web site at www.iea-retd.org.

From its genesis under the Clean Energy Ministerial in 2010, the International Smart Grid Action Network is the agency implementing agreement for a co-operative program on smart grids. This program is open to agency member and non-member countries and provides a mechanism for government-to-government collaboration on technologies, practices and systems and promotes the adoption of enabling government policies for smart grid. Canada is participating in three Annexes. CanmetENERGY is the official signatory body to the network and is providing a leadership role on the steering committee for these Annexes:

- Annex 1, Inventory of policy drivers and technology projects, is building a smart grid inventory of projects across all participating countries.
- Annex 2, Case study of smart grid demonstrations and pilots, presents in-depth case studies on several of those projects that are already achieving results and can offer valuable lessons learned and best practices.
- Annex 4, Insights for decision makers, will produce materials to support decision makers in making decisions about smart grid policy and programs and in engaging their stakeholders.

In addition to CanmetENERGY, SmartGrid Canada and the Ontario Ministry of Energy lead Canada's efforts on these initiatives.

International Partnership for Energy Efficiency Co-operation

NRCan participated in the development of the agreement establishing the International Partnership for Energy Efficiency Co-operation. This partnership of Canada and 14 other economies supports the on-going energy efficiency work of participating developed and emerging countries, which collectively account for over 75 percent of global gross domestic product and energy-use. The partnership's Executive Committee and Policy Committee both continued to meet in 2011–2012 and Canada was elected Policy Committee Chair for 2012–2013. A key component of the partnership's organizational structure is task groups that pursue projects that may interest most, but not all, member countries. Canada currently participates in the Global Superior Energy Performance Partnership and the Super-efficient Equipment and Appliance Deployment Task Groups.

In the Global Superior Energy Performance Partnership, participants are working to achieve continuous improvements in the energy performance of industrial facilities and commercial buildings, including through the implementation of energy management systems.

Super-efficient Equipment and Appliance Deployment partners are working to

- pull super-efficient appliances and equipment into the market through co-operation on measures like awards, procurement and incentives
- increase the efficiency levels of equipment and appliances by bolstering national or regional policies such as minimum efficiency standards and labelling programs
- strengthen programs through coordinated, cross-cutting technical analysis work

United Nations

NRCan contributes to the United Nations work on energy efficiency, alternative transportation fuels and renewable energy as opportunities arise.

An important Canadian contribution is RETScreen® International, which is managed under the leadership of CanmetENERGY. The RETScreen Clean Energy Project Analysis software, provided free-of-charge, can be used worldwide to evaluate the energy production and savings, costs, emission reductions, financial viability and risk for various types of renewable energy and energy-efficient technologies. RETScreen is managed through cost- and task-shared collaborative ventures with other governments and multilateral organizations and with technical support from more than 350 experts representing industry, government and academia. Key partners are the NASA Langley Research Center, the Renewable Energy and Energy Efficiency Partnership and the Energy Branch of the United Nations Environment Programme.

Asia-Pacific Economic Co-operation

Asia-Pacific Economic Co-operation is a dialogue group better known by its acronym: APEC. The OEE is a member of the APEC Expert Group on Energy Efficiency and Conservation, which reports to the APEC Energy Working Group. One of the key tasks of the expert group is updating and maintaining the APEC Energy Standards Information System. This database provides public information on the appliance and equipment energy standards and regulations of member countries. It also provides links to experts and information related to standards and regulations used by APEC members and other economies. NRCan contributes regularly to the database by providing updated information on Canadian equipment standards and labelling and new initiatives.

The OEE also provide annual updates to the *Compendium of Energy Efficiency Policies of APEC Economies*. The compendium is a comprehensive report on recent goals, action plans, policies and measures for energy efficiency improvements in 20 APEC economies. This allow for transparency in the implementation of the region's aggregate goal to reduce energy intensity by 45 percent between 2005 and 2035.

Clean Energy Ministerial

The Clean Energy Ministerial forum was launched by the United States in July 2010 to accelerate the world's transition to clean energy technologies. The

forum's initiatives cover three main areas: energy efficiency, clean energy supply and clean energy access. Initiatives are led by various countries and include participation from private sector partners and other organizations, such as the International Energy Agency.

Canada is active in four forum initiatives:

- Global Superior Energy Performance Partnership (also a task group under the International Partnership for Energy Efficiency Co-operation)
- Super-efficient Equipment and Appliance Deployment (also a task group under the International Partnership for Energy Efficiency Co-operation)
- Carbon Capture, Use and Storage Action Group
- International Smart Grid Action Network (also an International Energy Agency implementing agreement)

U.S.-Canada Clean Energy Dialogue

The U.S.-Canada Clean Energy Dialogue was launched by Prime Minister Harper and President Obama in February 2009. The objective of the dialogue is to enhance bilateral collaboration on the development of clean energy technologies to reduce greenhouse gas emissions. To implement the objectives, Action Plan I was presented to the leaders in September 2009.

NRCan participated in the three working groups that were created:

- Electricity Grid
- Clean Energy Research and Development
- Carbon Capture and Storage

After activities under Action Plan I were completed, Action Plan II was released to specify the next suite of activities for the coming years.

Under Action Plan I, the Electricity Grid Working Group focused on activities to facilitate the long-term transition to a modernized electricity system based on clean and renewable generation. Priority areas for collaboration included clean electricity trade; the smart grid and clean power technologies; power storage technologies; and capacity building in the electricity sector. In addition, during fiscal year 2011–2012, the working group completed a study of offshore, renewable energy regulatory frameworks of several European countries. Subsequently, the working group and the industry association Smart Grid Canada launched Canada's Smart Grid Repository – an online, publicly accessible compendium of information on smart grid projects implemented in Canada.

Research and development drives technological discovery and innovation, which are key ingredients in developing the low-carbon energy system of the future. During Action Plan I, the Clean Energy Research and Development Working Group facilitated greater cross-border research and development collaboration and policy dialogue by connecting Canadian and U.S. experts and institutions in priority areas for the Clean Energy Dialogue. The priority areas included future biofuels, clean engines and vehicles, and energy efficiency in homes and buildings. Also included is work to expand collaboration on the ENERGY STAR labelling program and develop a Canadian version of the U.S. ENERGY STAR building benchmarking program to help building owners, managers and operators and energy utilities track, benchmark and manage energy consumption. Strengthening collaboration in these areas through joint research, development and deployment will help reduce greenhouse gas emissions while strengthening both countries' economies and creating new jobs.

United States

In addition to collaborating through the Clean Energy Dialogue, Canada also meets annually with senior U.S. officials through the Canada-U.S. Energy Consultative Mechanism. This mechanism is a forum for dialogue on policy issues of interest to both countries.

NRCan's OEE signed a memorandum of understanding with the U.S. Environmental Protection Agency in September 2005. In it, they share the common goal of achieving greater energy efficiency and reducing greenhouse gas emissions through the work of their respective freight energy efficiency programs: FleetSmart and the SmartWay®

Transport Partnership. These two programs use a voluntary approach with the on-road freight sector to increase energy efficiency. Currently, the memorandum is being renewed to further the work on harmonizing program efforts under the SmartWay Transport Partnership in Canada and the United States.

APPENDIX 1

Natural Resources Canada's Energy Efficiency, Alternative Transportation Fuels and Renewable Energy Initiatives and Expenditures, 2011–2012

	(millions of dollars)
Energy Efficiency and Alternative Transportation Fuels[1]	**$418.9**
ecoENERGY Efficiency for Buildings	
ecoENERGY Efficiency for Housing	
ecoENERGY Efficiency for Equipment Standards and Labelling	
ecoENERGY Efficiency for Industry	
ecoENERGY Efficiency Vehicles	
ecoENERGY Retrofit – Homes	
ecoENERGY for Alternative Fuels	
ecoENERGY for Biofuels	
Federal Buildings Initiative	
National Energy Use Database	

	(millions of dollars)
Energy Efficiency – Energy Science and Technology[2]	**$75.9**
Clean Energy Systems for Buildings and Communities	
Clean Electric Power Generation	
Clean Energy Systems for Industry	
Environmentally Sustainable Oil and Gas	
Clean Transportation Energy	
Sustainable Bioenergy	
Alternative Energy – Renewable Energy Sources	**$552.6**
Pulp and Paper Green Transformation Program	
Investments in Forest Industry Transformation	
Marine Renewable Energy Enabling Measures Program	
Wind Power Production Incentive[3]	
Initiative to Purchase Electricity From Emerging Renewable Energy Sources[4]	
Total	**$1,047.4**

[1] The Energy Efficiency and Alternative Transportation Fuels total does not include the Sustainable Development Technology Canada – NextGen Biofuels Fund™. For details on this fund, see the text box on page 71.

[2] Totals allocated for the Program of Energy Research and Development, ecoENERGY Technology Initiative, ecoENERGY Innovation Initiative and the Clean Energy Fund in Chapter 4 are reflected in the relevant program entries.

[3] The Wind Power Production Incentive is fully committed, but incentives will be paid out to recipients up until 2016–2017.

[4] The Initiative to Purchase Electricity from Emerging Renewable Sources is fully committed, but incentives were paid out up until 2011–2012

APPENDIX 2

Data Presented in the Report

The aggregate energy use data presented in this report are taken from Statistics Canada's *Report on Energy Supply and Demand in Canada*. Some adjustments to the original Statistics Canada data were required and are documented in Appendix A of Natural Resources Canada's *Energy Use Data Handbook, 1990 to 2009*. The differences that exist between this report and *Canada's Energy Outlook* relate to the sector allocations of energy-use data from the *Report on Energy Supply and Demand in Canada.*

Figure 1-1: Secondary Energy Use by Sector, 2009

Sector	Industrial	Transportation	Residential	Commerical/ institutional	Agriculture	Total
Energy use (PJ)	3168.4	2576.6	1422.3	1186.0	188.3	8541.6
Percentage	37.1	30.2	16.7	13.9	2.2	100.0

Figure 1-2: Greenhouse Gas Emissions From Secondary Energy Use by Sector, 2009

Sector	Transportation	Industrial	Residential	Commerical/ institutional	Agriculture	Total
GHG emissions (Mt)	178.3	144.5	67.9	60.9	12.4	464.0
Percentage	38.0	31.0	15.0	13.0	3.0	100.0

Figure 1-3: Energy Intensity and the Energy Efficiency Effect, 1990 to 2009

Index (1990 = 1.00)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Energy intensity index	1.00	1.00	1.01	1.00	0.99	0.98	1.00	0.96	0.91	0.89	0.87	0.84	0.85	0.85	0.84	0.81	0.76	0.79	0.77	0.79
Index of energy efficiency effect	1.00	0.98	0.97	0.96	0.96	0.92	0.93	0.92	0.90	0.89	0.90	0.86	0.86	0.86	0.85	0.82	0.80	0.81	0.78	0.76

Figure 1-4: Secondary Energy Use, Actual and Without Energy Efficiency Improvements, 1990 to 2009

Index (1990 = 1.00)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Estimated secondary energy use without energy efficiency improvements	1.00	1.00	1.03	1.05	1.09	1.15	1.18	1.20	1.20	1.25	1.29	1.29	1.33	1.36	1.39	1.41	1.39	1.45	1.43	1.37
Actual energy use	1.00	0.98	1.00	1.02	1.05	1.07	1.11	1.11	1.09	1.13	1.17	1.14	1.18	1.22	1.24	1.23	1.19	1.27	1.25	1.23

Figure 1-5: Canadian Housing Stock by Building Type, 2009

Dwelling type	Housing stock by building type (thousands)	Percentage
Single detached homes	7835	56
Apartments	4294	31
Single attached homes	1549	11
Mobile homes	278	2
Total	**13 946**	**100**

Figure 1-6: Residential Energy Use by End Use, 2009

Activity	Energy use (PJ)	Percentage
Space heating	893.2	63
Water heating	245.8	17
Appliances	205.2	14
Lighting	60.6	4
Space cooling	17.4	1
Total	**1422.3**	**100**

Figure 1-7: Number of Households, Average Floor Space by Household and Energy Intensity Indexes, 1990 to 2009

Index (1990 = 1.00)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Households	1.00	1.03	1.05	1.07	1.08	1.10	1.12	1.13	1.14	1.16	1.18	1.20	1.21	1.23	1.25	1.27	1.29	1.31	1.33	1.36
Average floor space by household	1.00	1.00	1.01	1.01	1.02	1.02	1.03	1.03	1.03	1.03	1.02	1.02	1.02	1.02	1.04	1.06	1.08	1.09	1.10	1.09
Energy intensity (GJ/household)	1.00	0.96	0.97	0.98	0.98	0.95	1.01	0.96	0.86	0.89	0.92	0.87	0.89	0.91	0.88	0.86	0.81	0.86	0.86	0.82

Figure 1-8: Residential Energy Use, Actual and Without Energy Efficiency Improvements, 1990 to 2009

Index (1990 = 1.00)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Estimated energy use without energy efficiency improvements	1.00	1.04	1.10	1.14	1.14	1.17	1.22	1.20	1.13	1.17	1.24	1.21	1.28	1.31	1.33	1.36	1.33	1.42	1.45	1.48
Actual energy use	1.00	0.98	1.01	1.04	1.07	1.05	1.13	1.08	0.99	1.03	1.08	1.04	1.08	1.12	1.10	1.09	1.04	1.12	1.14	1.11

Figure 1-9: Average Energy Consumption of New Electric Appliances, 1990 and 2009 Models

Appliance	1990 model (KWh/yr)	2009 model (KWh/yr)
Refrigerator	956	430
Freezer	714	356
Dishwasher	277	88
Clothes washer	134	37
Clothes dryer	1103	921
Electric ranges	772	518

Figure 1-10: Commercial/institutional Energy Use by Activity Type,* 2009

Activity type	Energy use (PJ)	Percentage
Offices**	415.8	35
Retail trade	201.6	17
Educational services	149.4	13
Health care and social assistance	128.2	11
Accommodation and food services	88.1	7
Wholesale trade	71.8	6
Transportation and warehousing	46.2	4
Arts, entertainment and recreation	30.4	3
Information and cultural industries	25.7	2
Other services	21.0	2
Total	**1178.2**	**100**

*Excludes street lighting

** "Offices" includes activities related to finance and insurance; real estate and rental and leasing; professional, scientific and technical services; and public administration.

Figure 1-11: Commercial/institutional Energy Use by Purpose, 2009

Purpose	Energy use (PJ)	Percentage
Space heating	593.7	50
Auxiliary equipment	224.8	19
Lighting	126.0	11
Auxiliary motors	100.5	8
Water heating	95.6	8
Space cooling	37.8	3
Street lighting	7.8	1
Total	**1186.2**	**100**

Figure 1-12: Commercial/institutional Energy Use, Actual and Without Energy Efficiency Improvements, 1990 to 2009

Index (1990 = 1.00)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Estimated energy use without energy efficiency improvements	1.00	1.05	1.08	1.13	1.14	1.16	1.20	1.19	1.17	1.22	1.26	1.26	1.34	1.36	1.37	1.42	1.40	1.47	1.50	1.54
Actual energy use	1.00	1.03	1.04	1.08	1.07	1.11	1.13	1.15	1.09	1.13	1.24	1.22	1.31	1.35	1.35	1.34	1.26	1.34	1.38	1.37

Figure 1-13: Industrial Energy Use by Subsector – Including Electricity-related Emissions,* 2009

Subsector	Energy use (PJ)	Industrial energy use (%)
Mining	959.0	30.3
Other manufacturing**	635.9	20.1
Pulp and paper	560.4	17.7
Petroleum refining	315.1	9.9
Smelting and refining	231.5	7.3
Chemicals	185.3	5.8
Iron and steel	171.7	5.4
Construction and Forestry	62.2	2.0
Cement	47.4	1.5
Total	**3168.5**	**100.0**

* The subsectors reflect the current definitions in the *Report on Energy Supply and Demand in Canada*.

** "Other manufacturing" comprises more than 20 manufacturing industries.

Figure 1-14: Cost of Energy to Manufacturing Industries as a Percentage of Total Production Cost, 2009

Industry	Energy cost of total production cost (%)
Cement	22.5
Aluminum	10.4
Iron and steel	10.3
Pulp and paper	10.1
Chemicals	4.7
Petroleum refining	1.4
Transportation equipment and manufacturing	0.8

Figure 1-15: Industrial Energy Use, Actual and Without Energy Efficiency Improvements, 1990 to 2009

Index (1990 = 1.00)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Estimated energy use without energy efficiency improvements	1.00	1.00	1.02	1.04	1.10	1.14	1.15	1.15	1.16	1.20	1.23	1.26	1.29	1.33	1.33	1.34	1.33	1.39	1.40	1.39
Actual energy use	1.00	0.99	0.99	1.00	1.05	1.08	1.10	1.10	1.09	1.12	1.15	1.11	1.17	1.20	1.22	1.20	1.16	1.26	1.18	1.17

Figure 1-16: Industrial Energy Use, With and Without Energy Efficiency Improvements (Without Upstream Mining), 1990 to 2009

Index (1990 = 1.00)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Estimated energy use without energy efficiency improvements	1.00	1.01	1.02	1.01	1.09	1.13	1.13	1.12	1.13	1.17	1.20	1.21	1.25	1.27	1.26	1.26	1.22	1.29	1.29	1.27
Actual energy use	1.00	0.99	0.98	0.96	1.02	1.04	1.05	1.05	1.04	1.05	1.09	1.04	1.09	1.09	1.12	1.07	1.02	1.08	0.99	0.92

Figure 1-17: Transportation Energy Use by Mode, 2009

Mode	Energy use (PJ)	Percentage
Cars	639.9	
Passenger light trucks	467.6	
Motorcycles	4.3	
School buses	14.2	
Urban transit	32.4	
Intercity buses	5.9	
Passenger air	238.4	
Passenger rail	3.1	
Passenger total	**1405.8**	**54.6**
Freight light trucks	188.1	
Medium trucks	151.4	
Heavy trucks	560.6	
Freight air	4.7	
Freight rail	84.8	
Marine	88.0	
Freight total	**1077.6**	**41.8**
Off-road total	**93.2**	**3.6**
Total transportation energy use	**2576.6**	**100.0**

Figure 1-18: Market Shares of New Passenger Car and Light-Truck Sales, 1990 to 2009 (percentage)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Passenger car	74.2	74.8	72.3	69.3	66.9	64.8	62.5	59.5	58.9	60.8	62.9	63.4	62.7	62.2	61.7	61.7	61.2	59.6	61.4	58.9
Passenger light truck	25.8	25.2	27.7	30.7	33.1	35.2	37.5	40.5	41.1	39.2	37.1	36.6	37.3	37.8	38.3	38.3	38.8	40.4	38.6	41.1

Figure 1-19: Transportation Energy Use, Actual and Without Energy Efficiency Improvements, 1990 to 2009

Index (1990 = 1.00)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Estimated energy use without energy efficiency improvements	1.00	0.97	1.01	1.04	1.11	1.15	1.18	1.23	1.27	1.33	1.35	1.37	1.39	1.42	1.51	1.53	1.54	1.59	1.58	1.56
Actual energy use	1.00	0.96	0.99	1.00	1.05	1.07	1.09	1.13	1.17	1.20	1.22	1.21	1.23	1.26	1.31	1.33	1.33	1.38	1.38	1.37

Figure 1-20: Average Activity per Truck, 1990 to 2009 (tonne kilometres/truck)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Total medium- and heavy-duty truck vehicle activity	105 857	98 224	103 003	117 235	133 122	142 338	140 834	163 787	162 805	175 047	178 076	198 602	197 073	202 218	241 152	243 657	236 377	232 651	228 287	214 559

Figure 1-21: Trucking Energy Intensity, 1990 to 2009 (megajoules/tonne kilometre)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Total medium- and heavy-duty trucks energy intensity	3.75	3.78	3.78	3.62	3.41	3.48	3.41	3.33	3.17	3.02	3.04	2.84	2.81	2.92	2.61	2.64	2.73	2.84	2.94	3.05

Figure 2-1: Volume of Monthly Import Documents

Month	Total
Apr. 11	153 636
May 11	160 605
Jun. 11	169 903
Jul. 11	161 377
Aug. 11	171 319
Sep. 11	171 026
Oct. 11	175 552
Nov. 11	167 188
Dec. 11	166 106
Jan. 12	135 131
Feb. 12	139 418
Mar. 12	157 858
Total	**1 929 119**

Figure 2-4: ENERGY STAR Qualified Appliances as a Percentage of Total Shipments in Canada, 1999 to 2010

Appliance	1999 (%)	2000 (%)	2001 (%)	2002 (%)	2003 (%)	2004 (%)	2005 (%)	2006 (%)	2007 (%)	2008 (%)	2009 (%)	2010 (%)
Dishwashers	0.6	1.6	9.7	29.8	56.5	80.9	90.8	79.7	76.2	89.3	89.5	78.7
Clothes washers	1.9	2.2	9.2	22.1	30.6	36.2	45.9	50.8	58.4	64.4	69.4	65.9
Refrigerators	..	..	11.4	22.3	40.7	34.2	37.6	37.3	44.3	53.4	53.4	59.3

Figure 2-5: ENERGY STAR Awareness Levels in Canada, 2010

	Percentage
Aware – non-aided	71
Aware – aided	72

Figure 3-1: Number of R-2000 Housing Certifications and ENERGY STAR Prescriptive-labelled Houses, 1990 to 2011

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
R-2000 certified houses	495	699	1196	1299	784	610	416	484	265	213	319	329	428	379	583	500	439	483	557	541	360	440
ENERGY STAR labelled houses (prescriptive path only)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	878	1662	3888	4037	8794	8500

Figure 3-2: New Vehicle Fuel Efficiency Labelling

Year	On lot (%)	In showroom (%)
2007	78	56
2005	78	61
2001	77	56
1999	64	47

Figure 3-3: Company Average Fuel Consumption (CAFC) Versus Canadian Voluntary Standards, 1990 to 2010*

Model year	Truck standard (L/100 km)	Trucks CAFC (L/100 km)	Car standard (L/100 km)	Cars CAFC (L/100 km)
1990	11.8	11.3	8.6	8.2
1991	11.6	11.4	8.6	8.0
1992	11.6	11.1	8.6	8.1
1993	11.5	11.3	8.6	8.1
1994	11.5	11.1	8.6	8.2
1995	11.4	11.5	8.6	7.9
1996	11.4	11.5	8.6	7.9
1997	11.4	11.3	8.6	8.0
1998	11.4	11.4	8.6	7.9
1999	11.4	11.3	8.6	7.9
2000	11.4	11.1	8.6	7.8
2001	11.4	11.0	8.6	7.8
2002	11.4	11.0	8.6	7.7
2003	11.4	10.8	8.6	7.6
2004	11.4	10.7	8.6	7.5
2005	11.2	10.5	8.6	7.4
2006	10.9	10.4	8.6	7.5
2007	10.6	10.1	8.6	7.2
2008	10.5	9.5	8.6	7.1
2009	10.2	9.1	8.6	6.8
2010	10.0	8.5	8.6	6.8

*2009 and 2010 data are estimates.

Figure 3-4: Residential Energy Use and Energy Savings per Household, Pre-1945 to 2010–2012

	Pre-1945	1945–1959	1960–1969	1970–1979	1980–1989	1990–1999	2000–2009	2010–2012*	Average
Energy use pre-renovation (GJ)	269	200	187	173	171	161	147	131	192
Actual energy savings after renovations (GJ)	79	51	43	38	34	27	27	33	44

*Data for 2007 are from ecoENERGY Retrofit – Homes (previous data source was EnerGuide for Houses).

Figure 4-1: RETScreen Software: Cumulative Growth of User Base

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Canada	778	2265	3684	6050	9017	13 001	17 130	22 262	27 456	35 529	42 447	51 323	60 621	67 074
World total	**1841**	**5864**	**11 903**	**20 164**	**29 616**	**38 882**	**54 189**	**74 657**	**99 663**	**135 119**	**180 870**	**229 299**	**277 099**	**319 871**

Figure 5-1: Canadian Wind Power Capacity, 1993 to 2011 – Cumulative (MW)

	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Wind power capacity (MW, cumulative)	1	22	23	23	24	27	127	139	215	233	326	445	686	1459	1840	2337	3282	3967	5265

NOTES

NOTES

2300

Natural Resources Canada's Office of Energy Efficiency

Leading Canadians to Energy Efficiency at Home, at Work and on the Road

Canada